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NCBC GULFPORT
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GEOPHYSICAL INVESTIGATION OF SITES 1, 4 AND 5 NCBC GULFPORT MS

8/17/1995

GEOSPHERE MIDWEST INC

GEOPHYSICAL INVESTIGATION

OF

SITES 1, 4, AND 5 AT THE

NAVAL CONSTRUCTION BATTALION CENTER

(NCBC)

Gulfport, Mississippi

for

Morrison Knudsen Corporation

August 1995

GEOSPHERE MIDWEST INC
Brooklyn Park, Minnesota

GEOSPHERE INC GSI

17 August 1995

John McCumbers
Ulrich Cordon
Morrison Knudsen Corporation
2420 Mall Drive
Corporate Square 1, Suite 211
North Charleston, SC 29406

Re: Geophysical Investigation at NCBC, Gulfport, MS: Report Transmittal SC-4324-027 and CO No.1, CID001

Dear John and Ulrich:

We have completed our geophysical survey and report at the NCBC Facility in Gulfport, Mississippi. Detailed EM31 and EM61 color contour maps have identified many buried metallic targets at the three site areas 1, 4 and 5. Our anomaly maps for each site locate several primary zones which contain high concentrations of metallic objects and other landfilled materials. These figures also identify many more secondary metallic zones.

We recommend that the primary areas be investigated further, using drilling and trenching methods for confirmation of our results. The secondary target areas may also require investigation if the primary areas yield unwanted materials.

If we may assist you or your staff further, please call.

Sincerely,

Robert A. Glaccum
President

1748 sw 24th street miami florida 33145 tel: (305) 856-8022 fax: (305) 858-8235
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GEOPHYSICAL INVESTIGATION

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NAVAL CONSTRUCTION BATTALION CENTER

(NCBC)

Gulfport, Mississippi

for

Morrison Knudsen Corporation

August 1995

Morrison Knudsen N62467-93-D-1106
Geosphere Midwest 95-591

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EXECUTIVE SUMMARY

The Naval Construction Battalion Center (NCBC), located in the city of Gulfport, Mississippi, supports four battalions of the Naval Construction Force as well as the storage and maintenance of pre-positioned war reserve material stock. The facility encompasses over 1,000 acres which are used for residential, industrial, transportation, and training activities. Records indicate that three parcels in the western portion of the base have been used for debris and waste disposal during the period from 1942 to 1976; these three areas have been designated Sites 1, 4 and 5. Past disposal may have occurred in trenches or pits cut into the sandy/silty soils in these areas.

Survey: Each of the three sites were surveyed for the presence and delineation of buried wastes and metallic materials. Three geophysical instruments were employed for this purpose: 1) EM31 to map buried metal and conductive wastes/soils, 2) EM34 to locate any deeper (greater than 20 feet) conductive plumes, and 3) EM61 to identify zones of metallic burials. Each of the three sites were gridded with wooden stakes on 50x50 foot centers, followed by a finer grid along 10 foot parallel lines. Surveys were primarily conducted in a north-south direction along the 10 foot parallel grid lines with measurements taken every 2.5 feet for the EM31 survey, 5 feet for the EM34 survey and every 1.0 feet for the EM61 survey. At Site 5 the EM34 survey was made along east-west lines as were portions of the EM61 survey. At Sites 1 and 4, the EM34 survey was limited to 4 and 6 profile lines respectively due to the presence of many cultural interferences. The EM31, EM61 and Site 5 EM34 data were processed and contoured as color maps over a base map of each individual site.

Site 1 Results: The EM31 conductivity, EM31 inphase and EM61 contour maps (Figures 3.4, 3.5 and 3.6) clearly show several zones of metallic anomalies and buried utilities (pipelines). Such anomalies represent groups of large buried metal objects. The EM61 contour map also shows additional, weaker features which are indicative of smaller landfill debris (Figure 3.6). A composite anomaly map (Figure 3.7) identifies five primary and five secondary zones of fill. EM34 profiles revealed minor conductivity changes in the 10-50 foot depth regime, suggesting a very low probability for a deeper conductive plume.

Site 4 Results: The EM31 conductivity, EM31 inphase and EM61 contour maps (Figures 4.4, 4.5 and 4.6) identify several large zones of buried waste and metallic anomalies below and surrounding the putting/ninth greens, clubhouse area and cart shed. These anomalies represent very large concentrations of buried metal objects. The composite anomaly map (Figure 4.7) identifies four primary and eight secondary zones. The EM34 profiles revealed no significant trends or changes in deeper (10-50 foot) conductivities west of the drainage ditch.

Site 5 Results: The EM31 conductivity, EM31 inphase, EM34 conductivity, and EM61 contour maps (Figures 5.5, 5.6, 5.7 and 5.8) reveal areas of buried metallic waste in the central and southern portions of the site. Most of the features have dimensions similar to long disposal trenches or elongated pits. The EM61 contour map also shows additional, weaker anomalies which are indicative of smaller landfill debris (Figure 5.8). The composite anomaly map (Figure 5.9) identifies 11 primary and 13 secondary zones. The EM34 contours revealed thicker burial trenches containing large quantities of metal.

1 INTRODUCTION

1.1 LOCATION AND DESCRIPTION

The Naval Construction Battalion Center (NCBC) is situated in the city of Gulfport, located in the southeastern corner of Mississippi on the Gulf of Mexico. The Navy Base occupies over 1,000 acres in the west-central portion of Gulfport, approximately 3 miles from the Gulf and one mile west of Highway 49.

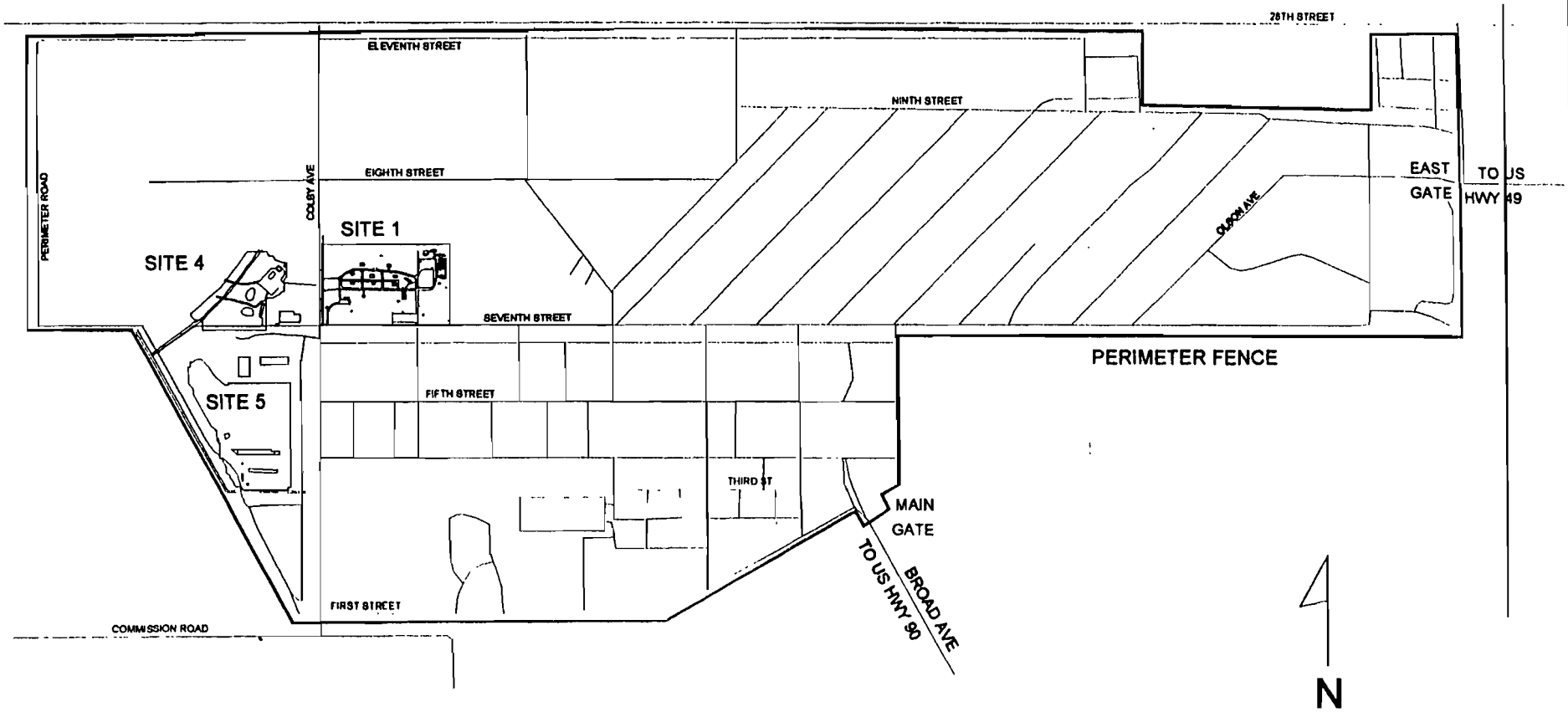
The NCBC base is home to four battalions of the Naval Construction Force and is also used for the storage and maintenance of pre-positioned war reserve material stock. The facility acreage is used for residential, industrial, transportation, storage, and training activities. Forests and wetlands also comprise portions of this acreage.

Historical information indicates that undeveloped land in the western part of the base was used for disposal of debris and waste materials. Three such parcels have been identified as having been active from 1942 to 1976; these areas are designated as Sites 1, 4 and 5 (Figure 1.1). It is believed that these landfills accepted a range of materials from hurricane debris to solid and liquid wastes, often contained in 55-gallon drums.

Site 1 is currently used as a disaster recovery training area; it is contains many 20-30 year old pine trees and several training buildings. The Site 4 landfill is situated below the eastern end of the NCBC golf course, in the vicinity of the clubhouse, putting and ninth greens, and maintenance sheds. Site 5 is an open area actively used for the training of SeaBee heavy equipment operators using bulldozers, cranes, drilling rigs, and graders; it is not vegetated and consists of reworked surface soils. Each area is described further in the following sections of the report.

1.2 PURPOSE

Geosphere Midwest was contracted to conduct a detailed geophysical survey of the three landfilled sites; this survey included coverage using EM31, EM34 and EM61 electromagnetic methods. The requested information included the presence and delineation of buried metallic materials (such as drums), conductive zones and general fill areas. Good signal levels (providing geophysical contrast) were expected between the sandy/silty soil and buried waste materials. Detection and mapping of conductive soils and ground-water plumes might also be expected in the EM31 and EM34 results. Surveys were conducted during the period 26 June through 18 July 1995.



GENERAL SITE LOCATION MAP	NCBC GULFPORT, MISSISSIPPI
SCALE 0 1000 2000 FT GEOSPHERE MIDWEST 7-22-95	LOCATION OF SITES 1, 4 & 5 FOR GEOPHYSICAL SURVEY

FIGURE 1.1

2 GEOPHYSICAL METHODS

2.1 GENERAL DESCRIPTION

Three electromagnetics methods were used at the NCBC Site in Gulfport, Mississippi:

1) EM31
2) EM34
3) EM61.

2.1.1 BASIC EM PRINCIPLES

The EM induction method determines electrical properties of earth materials by inducing electromagnetic currents in the ground and measuring the secondary magnetic field produced by these currents. An alternating current is generated in a wire loop or coil above the ground's surface. Both the primary magnetic field (produced by the transmitter coil in the instrument) and the secondary field (produced by currents in the earth) induce a corresponding alternating current in the receiver coil of the instrument. The coils are kept at a fixed distance and orientation to simplify handling of the data.

After compensating for the primary field (which can be computed from the relative orientations of both coils), both the magnitude and relative phase of the secondary field are measured. These measurements are then converted to components of inphase and 90 degrees (quadrature-phase) with the transmitted field. The quadrature-phase component, using certain simplifying assumptions, is converted to a measure of apparent ground conductivity. This apparent conductivity conversion assumes a homogeneous, isotropic earth. In practice, this value is an estimate of the average conductivity of the ground in the proximity of the instrument, to a depth of investigation (approximately 20 feet for the EM31 and 50 feet for the EM34) which is dependent on the instrument's coil spacing (3.66 meters for the EM31 and 10 meters for the EM34), operating frequency and the conductivity distribution of the earth. The inphase component provides a semi-quantitative measure of nearby metallic anomalies.

Data quality of the conductivity (quadrature) signal may be degraded by the presence of cultural interference such as that caused by utility lines, steel fences and large metallic objects whose high conductivity values may overwhelm the conductivity of the ground itself. Often, very high metallic responses will cause negative values in both the quadrature and inphase signals. The EM31 system produces a linear signal up to the 600 millimhos/meter level; the EM34 system produces a linear signal up to 65 millimhos/meter, higher conductivities may yield higher or lower readings.

2.2 EM31 AND EM34 ELECTROMAGNETICS

The EM31 instrument was employed to locate areas of shallow (0-20 feet) fill materials, contaminated soil and buried debris which have conductivity and inphase signals very different from natural soils. The EM34 was used to locate possible deeper conductive anomalies such as deeper waste pits and conductive plumes to depths of 50 feet. The presence of increased EM values divulge the location of concentrated amounts of electrolytes which are likely associated with bulk waste materials. EM signals also indicate metallic anomalies which may be in response to buried metallic objects such as drums, tanks and pipes which have high conductivity relative to typical soil conditions. The Geonics EM31 instrument was used as the primary tool for the following reasons:

1) provides conductivity information to 20 feet depth
2) is capable of resolving relatively small lateral features such as pipes and tanks
3) can be easily transferred to a digital recorder for near-continuous profile data.

2.2.1 EQUIPMENT

Electromagnetics measurements were taken with Geonics EM31 and EM34 systems used in the vertical dipole orientation mode at coil spacings of 3.66 and 10 meters respectively at operating frequencies fixed by the manufacturer. The instrument was connected to a digital data logger (OmniData Polycorder) to obtain and store data from multiple profile lines over the site. Readings were made at 2.5 and 5-foot intervals along these lines in units of millimhos/meter (mmhos/m). The maximum investigative depth of the EM31 instrument for single drum-sized targets is 5 to 10 feet (as stated by Geonics); quadrature sensitivity is reduced in areas which have conductive clayey soils. The EM34 data were taken along profiles at intervals of 5 feet using a special rigid boom system mounted on a 4x4 truck to permit rapid near-continuous data acquisition; depth of penetration is approximately 50 feet.

2.3 EM61 ELECTROMAGNETICS

The Geonics EM61 instrument was used to detect and map zones exhibiting metallic anomalies. The EM61 operates in a somewhat different manner than the EM31 and EM34 systems. The transmitter generates a pulsed primary magnetic field that induces eddy currents in the ground as well as in nearby metallic objects. The eddy currents produce a secondary field that decays with time after the termination of each primary field pulse. The receiver measures the strength of the secondary field produced by the eddy currents at a sufficiently long time after the start of the decay that the current induced in the ground has fully dissipated and only the eddy currents in nearby metal is measured. The system is sensitive to both ferrous and non-ferrous metal.

The Geonics literature states that the EM61 can detect a single 55-gallon drum to a maximum depth slightly greater than 10 feet. The response is a single sharp peak, providing high resolution data that can be used to accurately locate relatively small metal objects. Larger amplitude readings correspond to larger and/or shallower metal objects. The EM61 is relatively insensitive to nearby cultural features such as buildings, fences and power lines.

2.3.1 EQUIPMENT

The Geonics EM61 was employed over each site to provide a detailed map of buried metallic items. The sensing coils of the instrument were mounted to wheels and pulled around as a trailer along designated survey lines spaced 10 feet apart. Operated in this manner, measurements were made approximately every 1 foot along each line. The EM61 readings were displayed and recorded digitally on an OmniData recorder in units of millivolts for later computer processing.

3 SITE 1: DISASTER TRAINING AREA

3.1 SITE DESCRIPTION AND GRID SYSTEM

Site 1 is a flat wooded area used for SeaBee Disaster Recovery Training (DRT) activities. The site occupies approximately 20 acres and is located just north of Seventh Street and east of Colby Avenue in the western part of NCBC (Figure 3.1). The main disaster recovery training building is located in the northeastern portion of the site; nine smaller buildings are spread throughout the wooded, western part of Site 1 on a series of small paved access roads. One large asphalt parking lot is situated near the main DRT building (having two parked trucks); a second (student) lot is situated west of the entrance road near Seventh Avenue. Seven concrete pads containing steel mesh are also found scattered over the site; these are used for training platforms. Three sets of bleachers, two basketball poles, and four fire hydrants were also encountered (and plotted on the site map). Three monitor wells (GPT-1-1 through GPT-1-3) are located in the southern and northern portions of the area.

A concrete lined drainage ditch occupies the western edge of the site; two secondary ditches flow westward into this larger structure. Culvert pipes are present at most roadway intersections to accelerate drainage towards the west. Two former sewer structures (called catfish ponds) are located in an open area on the northern edge of the site. These 1,000 foot long structures are filled with concrete rubble and covered with clayey soil. The southern 150 feet of the site consists of dense brush and small pine trees; the northwest corner also consists of thick pines and heavy underbrush.

A coarse 50x50 foot grid was positioned over Site 1 using wooden stakes and surveyor tape. An east-west base line was established for 1200 feet along the northern edge of Seventh Street, coincident with a line of telephone poles; the north-south base line was positioned 20 feet east of Colby Avenue for a distance of 750 feet. The intersection of these two base lines was designated as the coordinate 3600E/3000N at a position northeast of the intersection of Seventh Street and Colby Avenue (Figure 3.1). When necessary, spray paint was used to designate the 50 foot grid nodes on asphalt and concrete areas. Gridding and geophysical field work were conducted during the period 1-18 July 1995.

3.2 GEOPHYSICAL DATA ACQUISITION

3.2.1 EM31

Using the Geonics EM31 instrument, 121 parallel EM lines were made over Site 1 in a north-south direction at a line spacing of 10 feet (Figure 3.2); readings were taken every 2.5 feet along each line. Both the quadrature (conductivity) and inphase signals of the instrument were simultaneously recorded on a digital (Omnidata Polycorder) data logger. Where appropriate, breaks in the lines were made for buildings and other surface obstacles. Finally, the data were

dumped to a field computer, assigned grid coordinates, processed, and plotted as quadrature conductivity and inphase (metal) contour maps. Processing included gridding and color contour plotting using Golden Software's Winsurfer program. Individual EM31 profile lines are given in Appendix B.

3.2.2 EM34

Following a preliminary review of EM31 contour maps, it became apparent that many areas of the site were subject to interference from buried utility lines, buildings, and steel reinforced concrete pads and sidewalks which would seriously impair any large scale coverage by EM34. Therefore, certain areas of the site were selected for limited followup profiles with the truck-boom EM34 system. These included the north-central, south-central and eastern portions of the site. Three parallel lines were made in an east-west direction; one line was also run in the north-south direction on the entrance road in the eastern part of the site (see Figure 3.2). Readings were taken every 5 feet along each line. Output from the EM34 was recorded on a digital (Omnidata Polycorder) data logger. The data were dumped to a field computer, assigned grid coordinates, processed, and plotted as a series of profile lines. Individual EM34 profile lines are given in Appendix C.

3.2.3 EM61

Using the Geonics EM61 instrument, parallel lines were run across the site in a north-south direction at a line spacing of 10 feet (Figure 3.3); readings were taken every 1 foot along each line. Data were recorded on a digital (Omnidata Polycorder) data logger. Finally, the data were periodically dumped to a field computer, assigned grid coordinates, processed, and plotted as EM61 metal response contour maps. Processing included gridding and color contour plotting using Golden Software's Winsurfer program. Individual EM61 profile lines are given in Appendix D.

3.3 EM31 RESULTS

The processed EM31 data are presented as conductivity and inphase contour maps shown in Figures 3.4 and 3.5. The contours have been plotted in color over a detailed base map of the site along with the geophysical grid system to assist in identifying locations of anomalous conditions. Typically, in landfilled areas, EM conductivity contours represent a large deviation from background conditions, ranging from high values over conductive fill to negative values over buried metal and reinforced concrete. The range of inphase contours represents zones of surface and buried metallic objects/utilities, which may have either high positive or negative values.

3.3.1 UTILITY CORRELATION

Analysis of Figures 3.4 and 3.5 reveal the presence of several characteristic EM features:

a) buried utility lines
b) buildings (and bleachers)

c) reinforced concrete pads, culverts and sidewalks
d) known debris burial (in the catfish ponds)
e) singular objects such as fire hydrants and other known steel objects.
f) anomalies caused by buried materials.

The dominant EM contour features are strong responses caused by pipelines, buildings, reinforced concrete pads and sidewalks, catfish pond debris, and road culvert pipes (Figures 3.4 and 3.5). These EM responses can be correlated to known features identified in the field and on the site base map. Linear features may be interpreted as representations of buried utilities, some of which are known from site utility maps and still others which are surmised from surface features such as fire hydrants (Figures 3.4 and 3.5). Irregular EM conductivity and inphase anomalies which do not appear to be associated with known or interpreted utility lines are potential zones of buried metal materials.

Six linear features characteristic of buried pipelines are evident at Site 1. The strongest feature appears as an east-west, positive/negative anomaly along grid line 3100N and parallel to Seventh Street; this line appears to connect with a pumphouse located at grid coordinates 3650E/3150N. A second strong pipeline-like feature extends north-south along grid line 3650E from Seventh Street to the pumphouse; a smaller pipe also appears to extend northward from the pumphouse to the former catfish pond area. The third interpreted water pipeline feature runs east-west across the site along grid lines 3400N and 3350N, apparently connecting to the fire hydrant at coordinates 4710E/3345N. The fourth interpreted pipeline extends diagonally across the western half of the site from the pumphouse area to the center of the site, supplying the hydrant at coordinates 3960E/3320N and perhaps supplying the third pipeline at coordinates 4075E/3400N. The fifth water line is found parallel to grid line 3620N, feeding the fire hydrant at coordinates 4620E/3615N. High EM31 readings along the eastern boundary of the site (grid line 4800E) are likely caused by a sixth north-south water line located just east of the grid's edge.

Each building and concrete pad is surrounded by a halo of strong positive/negative values; sidewalks and road culverts may be recognized by their strong negative readings. The remaining unexplained features (all negative readings) should be considered potential zones of buried metallic wastes.

3.3.2 BURIED MATERIAL

No laterally extensive EM anomalies were detected which might indicate massive burial trenches; however, nine large and irregular-shaped EM anomalies were found in the western, south-central and southeastern sections of the Site 1 (see Figures 3.4 and 3.5). These may represent high concentrations of large metallic objects in burial pits approximately 20x50 feet in size. Other smaller EM31 anomalies in these same areas may also indicate burial pits with dimensions on the order of 10x20 feet.

1) Of particular concern are the five large and four smaller anomalies in the south-central section. They are located at coordinates:

LARGE ANOMALIES	SMALLER ANOMALIES
4050E/3200N	4175E/3140N	3990E/3190N	4200E/3050N
4060E/3160N	4225E/3050N	4310E/3065N	4360E/3060N
	4260E/3160N		

This group of anomalies appears to be associated with a much larger landfilled area seen in the EM61 results (see Report Section 3.5.2).

2) Also of interest are the one large and two small anomalies centered at coordinates 3800E/3320N. These features appear to be part of another landfilled area.

3) One isolated, large anomaly is located near the southeast corner of one of the training support buildings at coordinates 4410E/3215N.

4) The two remaining large anomalies (near coordinates 4600E/3040N) may be part of a larger trench. The strong negative values suggest the presence of considerable buried metal.

5) A group of two small and very small anomalies is centered near coordinates 4600E/3170N.

6) Another group of small EM31 anomalies is present near the main Disaster Recovery Training building at coordinates 4625E/3420N.

7) Four other small anomalous zones are located at coordinates 4140E/3495N, 4450E/3590N, 4360E/3475N, and 3710E/3375N.

3.4 EM34 RESULTS

The EM34 results for Site 1 are presented in profile form in Figure C-1 in Appendix C. Lines 3200N, 3330N, 3460N and 3700N represent the long east-west profiles across the site. Line 4500E is the north-south profile acquired along the Disaster Recovery entrance road. Both EM conductivity and inphase measurements are presented together with the conductivity scale (in millimhos/meter) on the left side and the inphase scale (in ppt) on the right side of the plot.

In Line 3200N, the EM34 conductivity values are relatively flat except for the western and extreme eastern portions of the plot. The abrupt negative trends at Stations 3690E and 4790E are caused by buried water pipelines (as determined by EM31 results). The sharp negative tending anomaly at Station 4050E is the EM34's response over one of the large negative anomalies (burial areas) described in the EM31 results. The sharp positive peak in the inphase data between Stations 3850 and 3890 was caused by the close proximity of a metallic work trailer at this location.

Line 3330N was run along the southern most site road; the anomaly at Station 4080 is in response to a pipeline crossing and the smaller anomaly at Station 4370 is caused by a nearby

culvert and metal building. Line 3460N was run along the northern most site road starting near the main Disaster Recovery Training Building, which caused the sharp deflections at Station 4650E. The smaller anomalies between Stations 4460E and 4490E are caused by the large culvert under the entrance roadway. Minor anomalies at Station 4200E are caused by unknown conditions (which correlate to EM61 anomalies, discussed in Section 3.5.2).

Line 3700N was run over the open area north of the pine woods; this area is known to be underlain by the former catfish ponds and their fill materials. Low amplitude but distinctive anomalies are observed along the entire length of Line 3700N. Line 4500E shows relatively flat values except where the line crossed water pipelines at Stations 3080N and 3350N and came into close proximity to the parked truck at Station 3590N.

In summary, these limited profile lines reveal that deeper (10-50 feet) conductivities (in areas not influenced by metallic materials) are relatively constant across the site. Consequently, no evidence exists for deeper pits or a deeper conductive anomaly (plume) in the 10-50 foot soil/ground water system.

3.5 EM61 RESULTS

3.5.1 CORRELATION TO KNOWN OBJECTS

The processed EM61 data are presented in Figure 3.6. Higher value contours generally represent higher concentrations of buried metal or shallower metal objects. Most metal responses are recorded from depths in the range of 0 to 10 feet. Responses recorded by the EM61 are typically very "tight", ie, high values only occur over and immediately adjacent to the suspected target (whereas EM31 readings may be influenced up to 15-20 feet from the utility or surface metal).

Analysis of the metal response contours in Figure 3.6 shows correlations with features observed in the EM conductivity and inphase maps (Figures 3.4 and 3.5):

a) utilities
b) buildings
c) reinforced concrete pads and sidewalks
d) construction debris in the catfish ponds
e) singular metallic anomalies.

Contours in Figure 3.6 offer a more distinct outline of the buried water pipelines when compared to the EM31 results. Other known features such as building edges, culverts, sidewalks and fire hydrants are also well defined.

3.5.2 BURIED MATERIAL

In analyzing the data for unknown buried materials, the EM61 result reveals a considerable number of low amplitude contours and a moderate number of stronger (higher) readings. As seen in Figure 3.6, the pale and light blue contours represent low instrument readings from 13 to 50

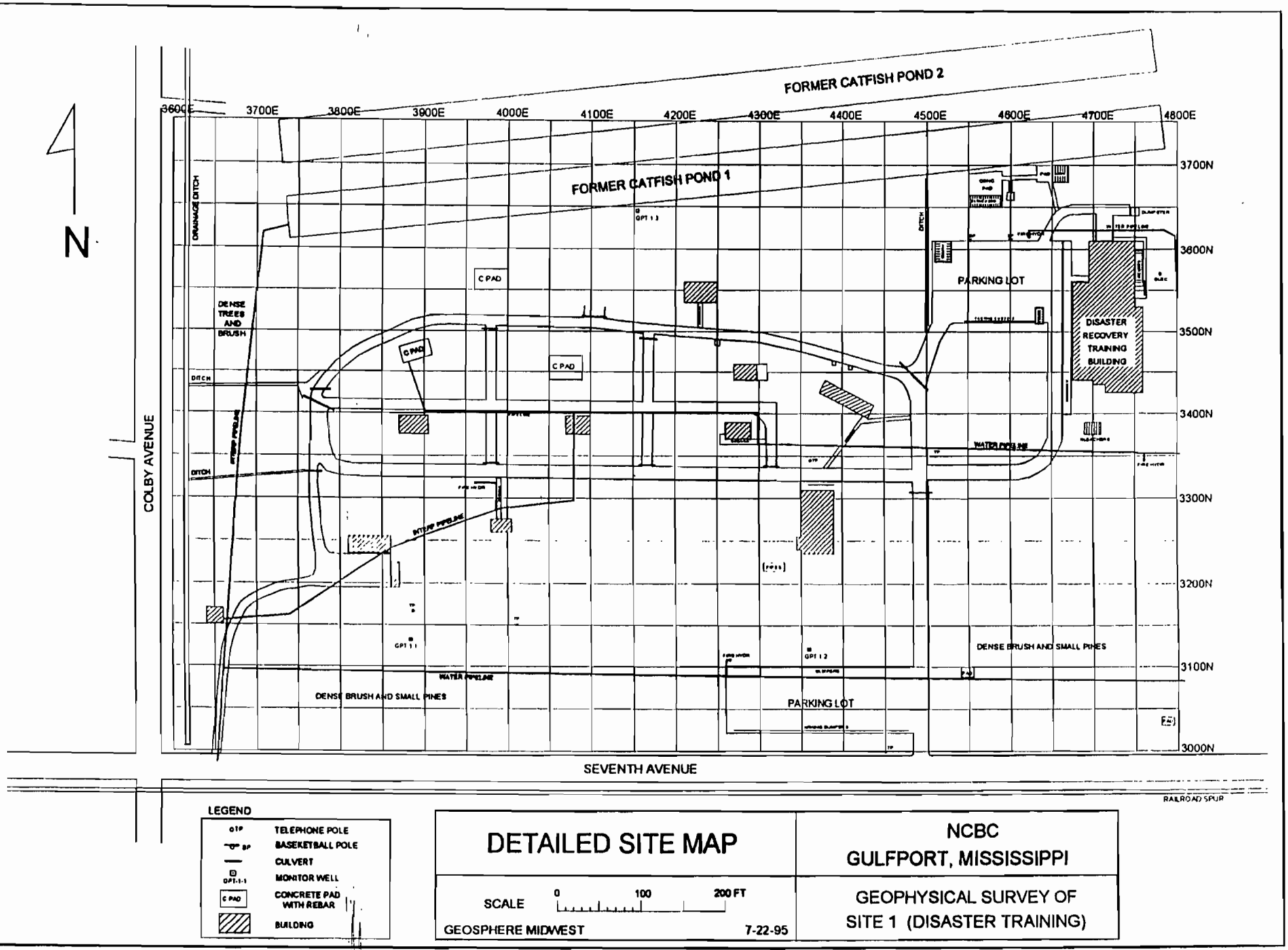
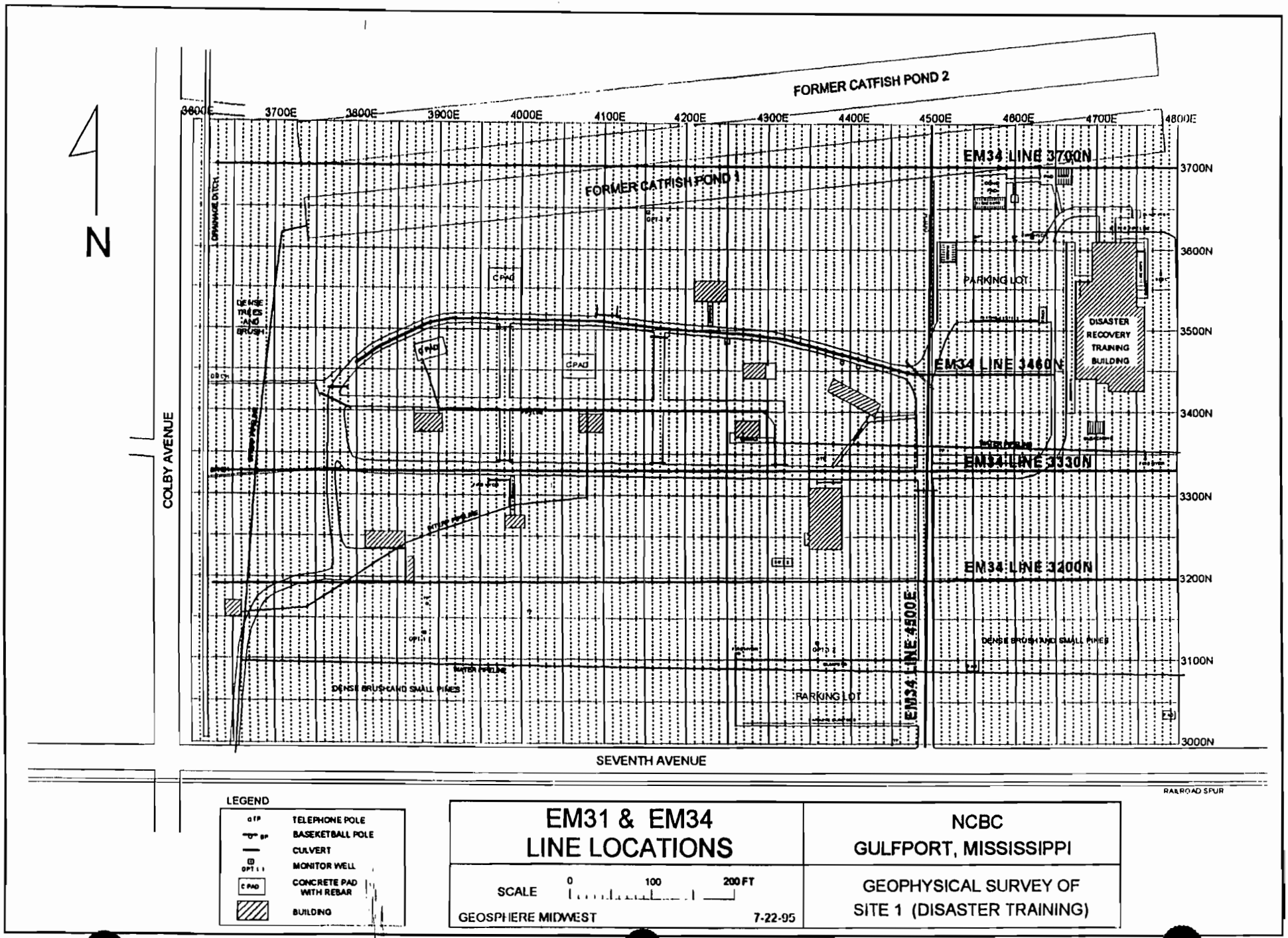

N
FORMER CATFISH POND 2
FORMER CATFISH POND 1
3600E
3700E
3800E
3900E
4000E
4100E
4200E
4300E
4400E
4500E
4600E
4700E
4800E
3700N
3600N
3500N
3400N
3300N
3200N
3100N
3000N
DRAINAGE DITCH
COLBY AVENUE
DENSE TREES AND BRUSH
C PAD
C PAD
C PAD
DITCH
DITCH
PARKING LOT
DISASTER RECOVERY TRAINING BUILDING
WATER PIPELINE
DENSE BRUSH AND SMALL PINES
DENSE BRUSH AND SMALL PINES
PARKING LOT
SEVENTH AVENUE
RAILROAD SPUR
LEGEND
TELEPHONE POLE
BASEKETBALL POLE
CULVERT
MONITOR WELL
CONCRETE PAD WITH REBAR
BUILDING
DETAILED SITE MAP
SCALE 0 100 200 FT
GEOSPHERE MIDWEST 7-22-95
NCBC
GULFPORT, MISSISSIPPI
GEOPHYSICAL SURVEY OF
SITE 1 (DISASTER TRAINING)

FIGURE 3.1


N
FORMER CATFISH POND 2
FORMER CATFISH POND 1
3600E
3700E
3800E
3900E
4000E
4100E
4200E
4300E
4400E
4500E
4600E
4700E
4800E
EM34 LINE 3700N
EM34 LINE 3460N
EM34 LINE 3330N
EM34 LINE 3200N
EM34 LINE 4500E
3700N
3600N
3500N
3400N
3300N
3200N
3100N
3000N
PARKING LOT
DISASTER RECOVERY TRAINING BUILDING
DENSE TREES AND BRUSH
DRAINAGE DITCH
CPAD
COLBY AVENUE
DENSE BRUSH AND SMALL PINES
SEVENTH AVENUE
RAILROAD SPUR
LEGEND
TELEPHONE POLE
BASEKETBALL POLE
CULVERT
MONITOR WELL
CONCRETE PAD WITH REBAR
BUILDING
EM31 & EM34
LINE LOCATIONS
SCALE 0 100 200 FT
GEOSPHERE MIDWEST 7-22-95
NCBC
GULFPORT, MISSISSIPPI
GEOPHYSICAL SURVEY OF
SITE 1 (DISASTER TRAINING)

14

IRE 3 2

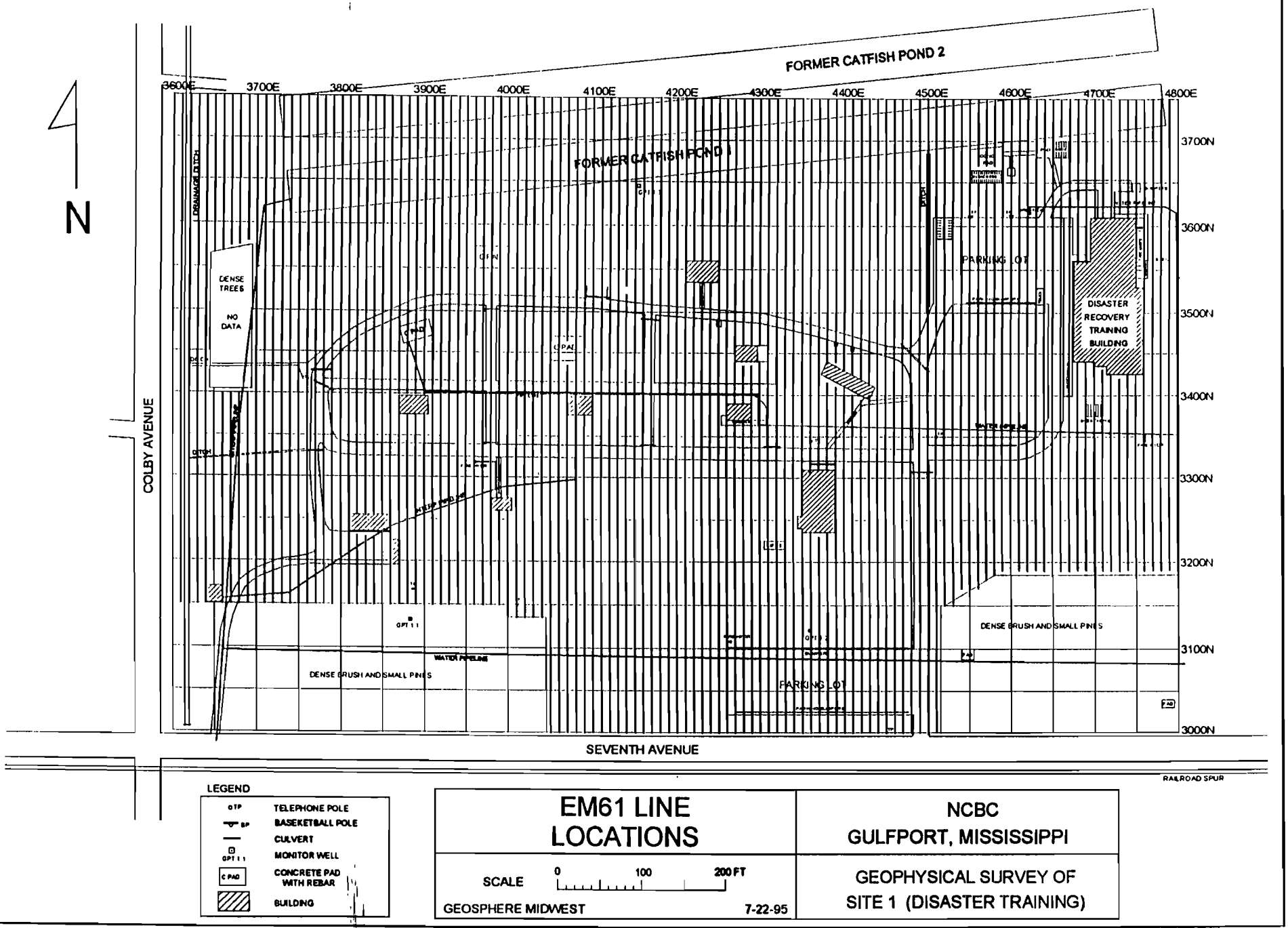
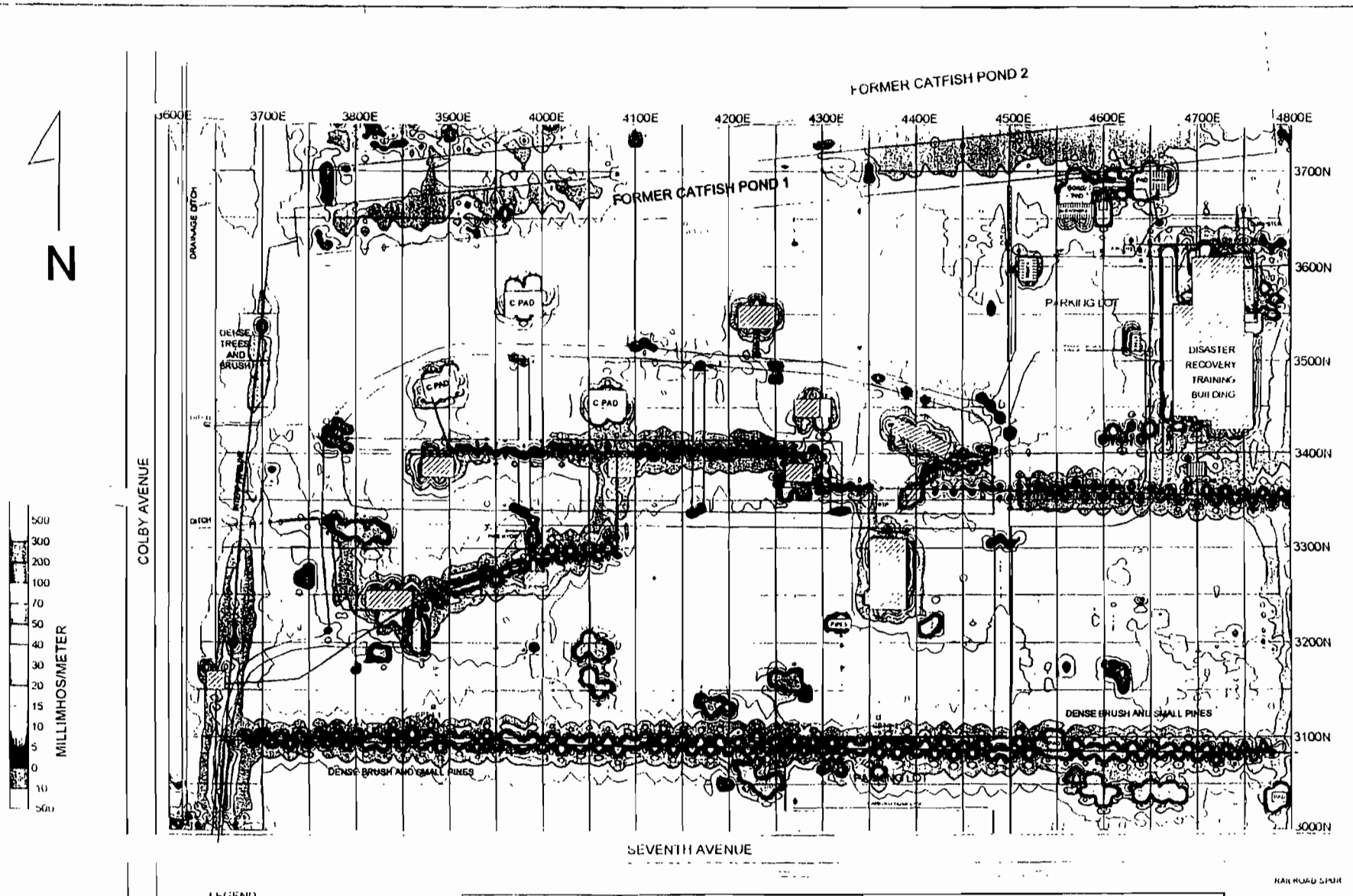

N
FORMER CATFISH POND 2
FORMER CATFISH POND 1
3600E
3700E
3800E
3900E
4000E
4100E
4200E
4300E
4400E
4500E
4600E
4700E
4800E
3700N
3600N
3500N
3400N
3300N
3200N
3100N
3000N
COLBY AVENUE
SEVENTH AVENUE
RAILROAD SPUR
DRAINAGE DITCH
DENSE TREES
NO DATA
PARKING LOT
DISASTER RECOVERY TRAINING BUILDING
DENSE BRUSH AND SMALL PINES
WATER PIPELINE
DITCH
C PAD
LEGEND
TELEPHONE POLE
BASEKETBALL POLE
CULVERT
MONITOR WELL
CONCRETE PAD WITH REBAR
BUILDING
EM61 LINE LOCATIONS
SCALE
0
100
200 FT
GEOSPHERE MIDWEST
7-22-95
NCBC
GULFPORT, MISSISSIPPI
GEOPHYSICAL SURVEY OF
SITE 1 (DISASTER TRAINING)

FIGURE 3.3



EM31 CONDUCTIVITY CONTOUR MAP

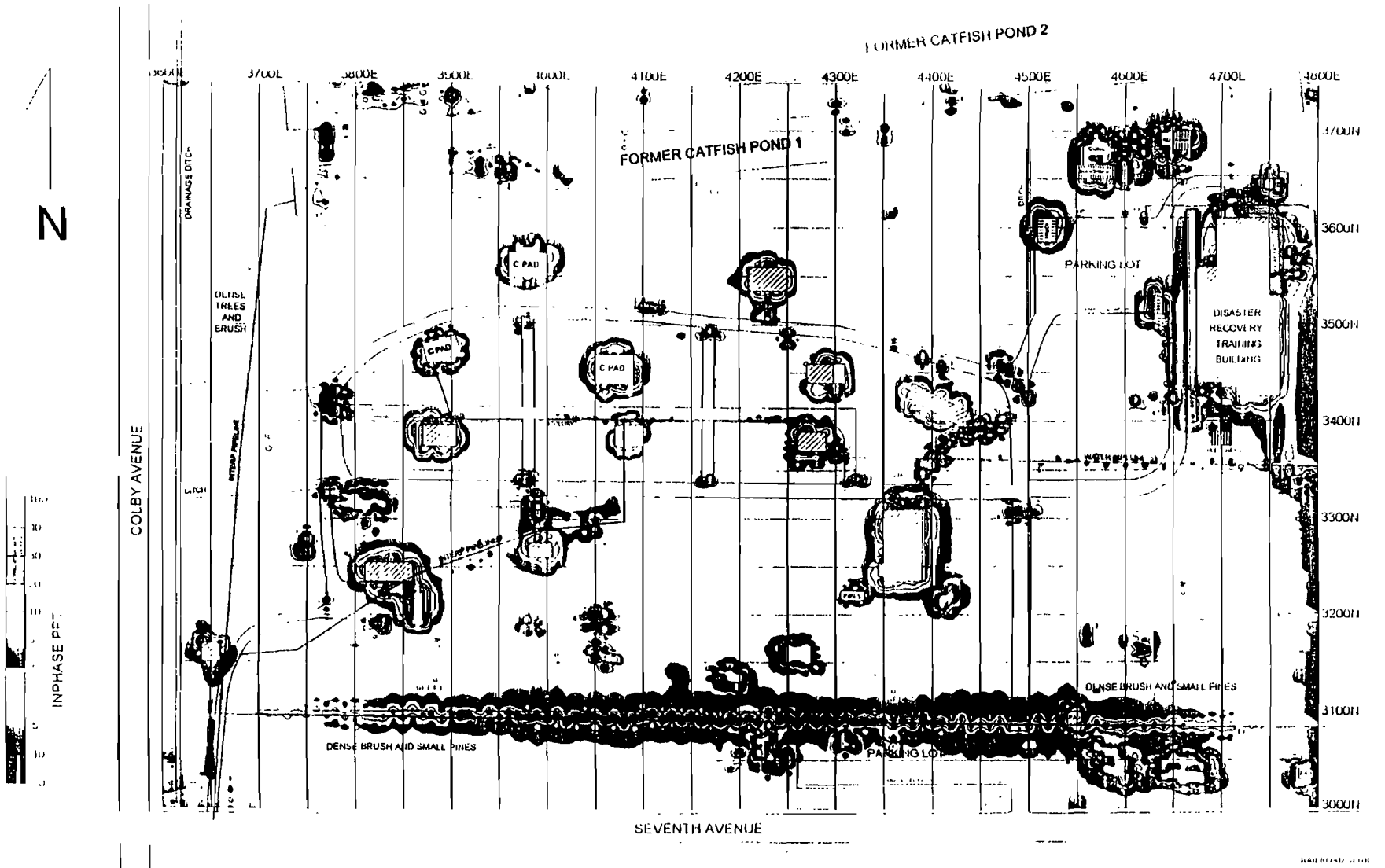
SCALE 0 100 200 FT

GEOSPHERE MIDWEST 7-22-95

NCBC
GULFPORT, MISSISSIPPI

GEOPHYSICAL SURVEY OF
SITE 1 (DISASTER TRAINING)

FIGURE 3-1


FORMER CATFISH POND 2
FORMER CATFISH POND 1
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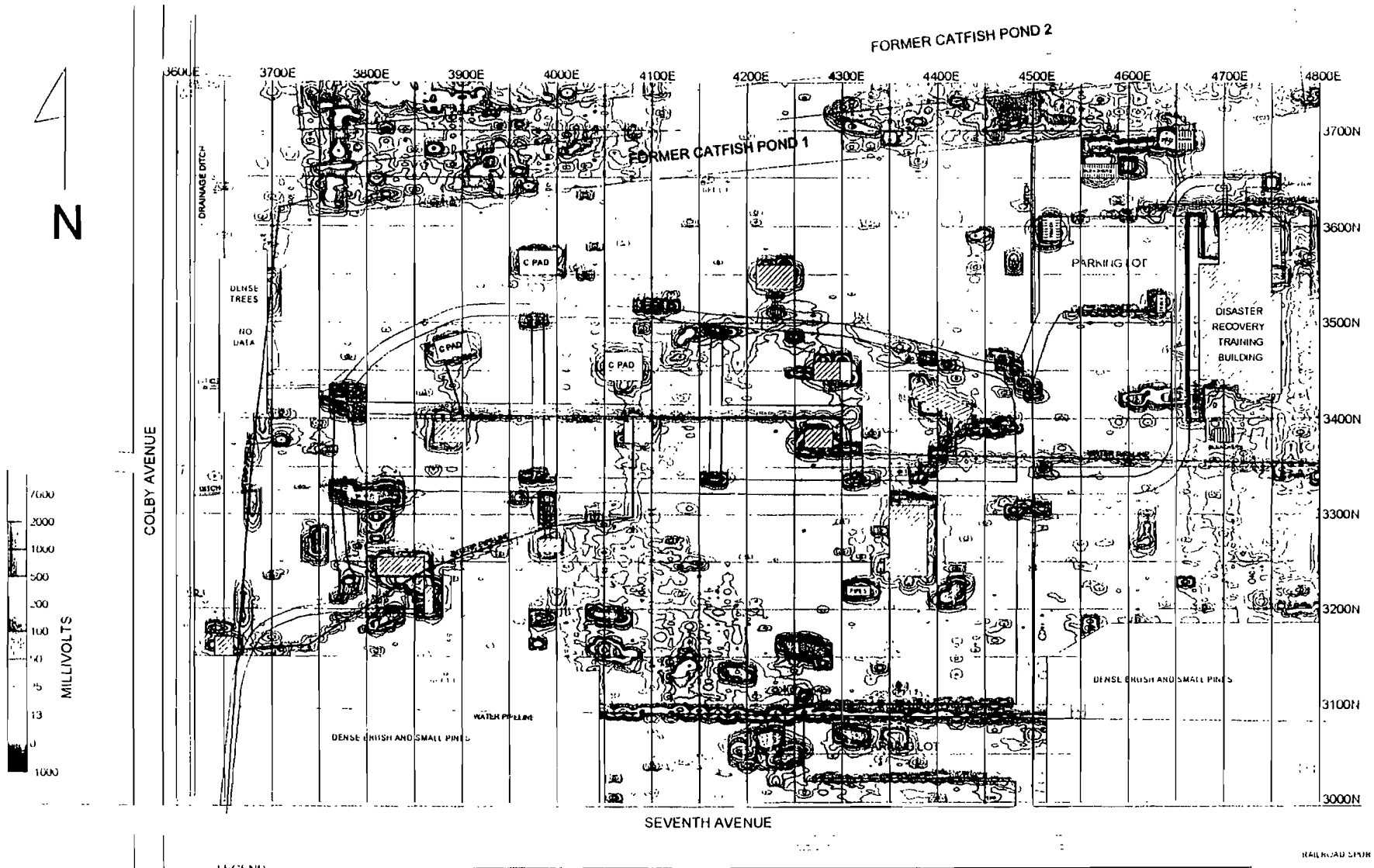
4000E
4100E
4200E
4300E
4400E
4500E
4600E
4700E
4800E
3700N
3600N
3500N
3400N
3300N
3200N
3100N
3000N
N
COLBY AVENUE
DRAINAGE DITCH
DENSE TREES AND BRUSH
C PAD
PARKING LOT
DISASTER RECOVERY TRAINING BUILDING
DENSE BRUSH AND SMALL PINES
SEVENTH AVENUE
INPHASE PPT
LEGEND
TELEPHONE POLE
BASEKETBALL POLE
CULVERT
MONITOR WELL
CONCRETE PAD WITH REBAR
BUILDING
EM31 INPHASE METAL CONTOUR MAP
SCALE 0 100 200 FT
GEOSPHERE MIDWEST 7-22-95
NCBC
GULFPORT, MISSISSIPPI
GEOPHYSICAL SURVEY OF
SITE 1 (DISASTER TRAINING)

FIGURE 3.5



EM61 METAL RESPONSE CONTOUR MAP

NCBC
GULFPORT, MISSISSIPPI

GEOPHYSICAL SURVEY OF
SITE 1 (DISASTER TRAINING)

FIGURE 3.6

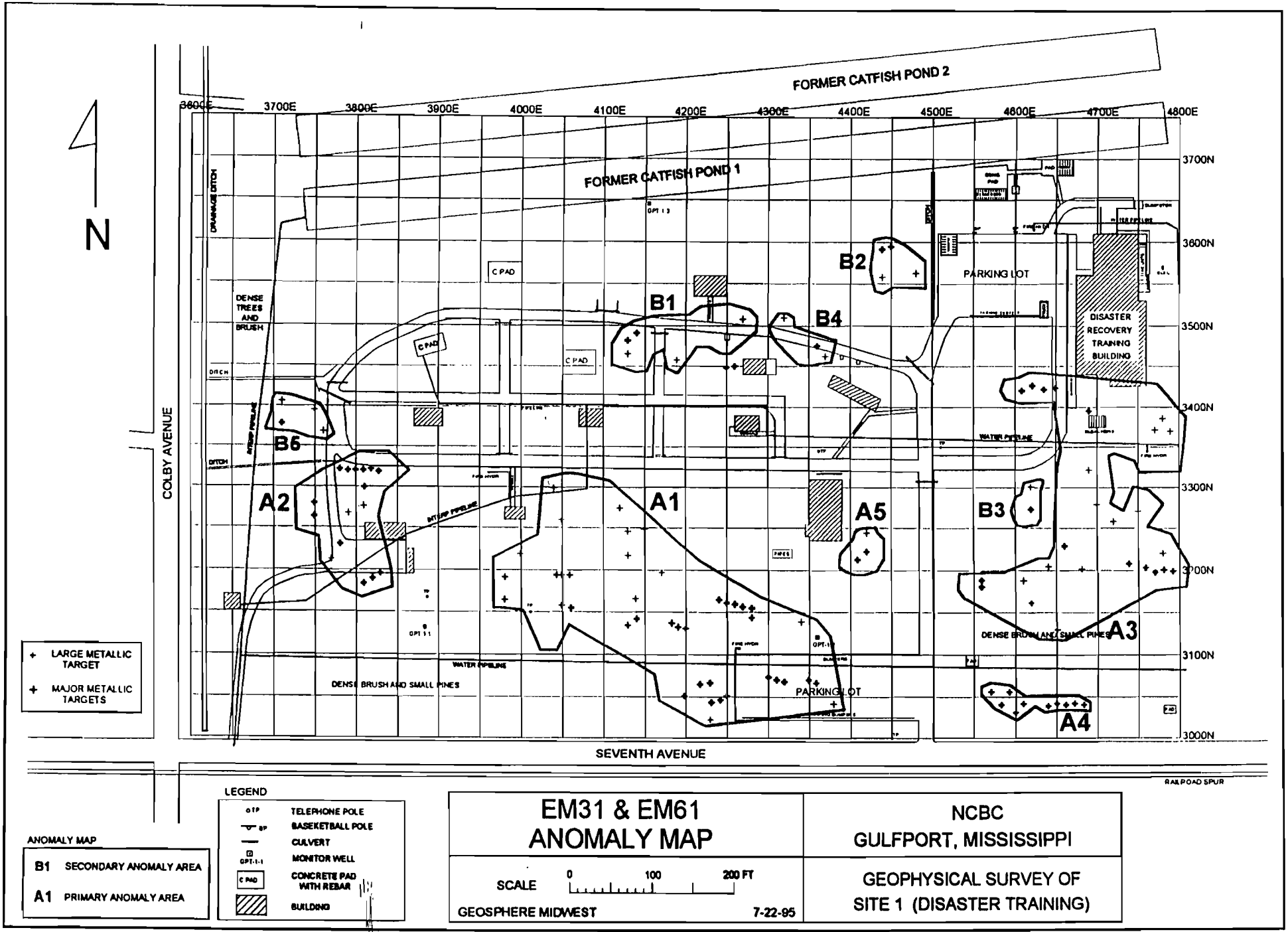

N
FORMER CATFISH POND 2
FORMER CATFISH POND 1
3600E
3700E
3800E
3900E
4000E
4100E
4200E
4300E
4400E
4500E
4600E
4700E
4800E
3700N
3600N
3500N
3400N
3300N
3200N
3100N
3000N
DRAINAGE DITCH
COLBY AVENUE
SEVENTH AVENUE
RAILROAD SPUR
DENSE TREES AND BRUSH
C PAD
PARKING LOT
DISASTER RECOVERY TRAINING BUILDING
WATER PIPELINE
DENSE BRUSH AND SMALL PINES
B1
B2
B3
B4
B5
A1
A2
A3
A4
A5
LARGE METALLIC TARGET
MAJOR METALLIC TARGETS
LEGEND
TELEPHONE POLE
BASEKETBALL POLE
CULVERT
MONITOR WELL
CONCRETE PAD WITH REBAR
BUILDING
ANOMALY MAP
B1 SECONDARY ANOMALY AREA
A1 PRIMARY ANOMALY AREA
EM31 & EM61
ANOMALY MAP
SCALE 0 100 200 FT
GEOSPHERE MIDWEST 7-22-95
NCBC
GULFPORT, MISSISSIPPI
GEOPHYSICAL SURVEY OF
SITE 1 (DISASTER TRAINING)

FIGURE 3.7

4 SITE 4: GOLF COURSE

4.1 SITE DESCRIPTION AND GRID SYSTEM

Site 4 is an open and wooded area currently used for the eastern portion of NCBC's nine hole golf course. The site occupies approximately 5.8 acres and is located immediately north of Seventh Street and about 350 feet west of Colby Avenue in the western part of NCBC (Figure 1.1). Structures on the site include the main clubhouse building, storage shed and a golf cart recharging shed. A large maintenance building and fenced compound is located on the southeastern boundary of the site (Figure 4.1). A large asphalt parking lot is situated south of the clubhouse, connected to Colby Avenue by a paved driveway. A small, above ground petroleum storage tank is located in the northeastern corner of the site, near the northern storage shed. Two fire hydrants are also located on site as are three monitor wells (GPT-4-1 through GPT-4-3); these are located in the southern and central portions of Site 4.

An unlined drainage ditch occupies the western edge of the site; two small bridges cross this ditch to permit golfers access to the main fairways on the west side. A driving range extends northwest of the site. A raised embankment immediately east of the ditch rises approximately eight feet above the level of the ditch; the clubhouse, driving range tee, putting green, and ninth green are also situated on fill above the natural ground surface. West of the ditch, surface elevations rise less than three feet. Dense brush, thorny vines and pine woods exist along the northern and eastern edges of the active golf course area. The geophysical survey was not conducted in these vegetated areas due to the extensive effort required to clear brush and trees.

A coarse 50x50 foot grid was positioned over Site 4 using wooden stakes and surveyor tape. An east-west base line was established for 1,000 feet along the northern edge of Seventh Street, coincident with a line of telephone poles to the east. The north-south base line was positioned 50 feet east of Monitor Well GPT-4-2 and 600 feet west of the Site 1 base line (grid line 3600E, located 20 feet east of Colby Avenue); the Site 4 base lined extended north for a distance of 700 feet. The intersection of these two base lines was designated as the coordinates 3000E/3000N (Figure 4.1). When necessary, spray paint was used to designate the 50 foot grid nodes on asphalt and concrete areas. Gridding and geophysical field work were conducted during the period 26 June through 17 July 1995.

4.2 GEOPHYSICAL DATA ACQUISITION

4.2.1 EM31

Using the Geonics EM31 instrument, 79 parallel EM lines were made over Site 4 in a north-south direction at a line spacing of 10 feet; three profile lines were also run southwest-northeast and three southeast-northwest in the fairways west of the ditch (Figure 4.2). Readings were taken every 2.5 feet along each line. Both the quadrature (conductivity) and inphase signals of the

instrument were simultaneously recorded on a digital (Omnidata Polycorder) data logger. Where necessary, breaks in the lines were made for buildings and other surface obstacles. Finally, the data were dumped to a field computer, assigned grid coordinates, processed, and plotted as quadrature conductivity and inphase (metal) contour maps. Processing included gridding and color contour plotting using Golden Software's Winsurfer program. Individual EM31 profile lines are given in Appendix E.

4.2.2 EM34

Following a preliminary review of EM31 contour maps, it became apparent that many areas of the site were subject to interference from buried utility lines, buildings, and the massive amount of conductive, metallic waste which would seriously degrade data acquired by the EM34 system. Because deeper conductive contaminants may have migrated towards the west, the area west of the drainage ditch was selected for limited followup profiles with the truck-boom EM34 system. Three parallel lines (Lines 1-3) were made in a southwest-northeast direction, parallel to the ditch (coincident with EM31 line locations west of the ditch); three additional lines (Lines 4-6) were also run perpendicular to these in a southeast-northwest direction (see Figure 4.2). Readings were taken every 5 feet along each line. Output from the EM34 was recorded on a digital (Omnidata Polycorder) data logger. The data were dumped to a field computer, assigned grid coordinates, processed, and plotted as a series of profile lines. Individual EM34 profile lines are given in Appendix F.

4.2.3 EM61

Seventy-eight parallel EM61 lines were run across the site in a north-south direction at a line spacing of 10 feet (Figure 4.3); readings were taken approximately every 1 foot along each line. Data were recorded on a digital (Omnidata Polycorder) data logger. Because no significant metallic signatures were found in the preliminary EM31 plots west of the drainage ditch, this area was not surveyed with the EM61. The data were periodically dumped to a field computer, assigned grid coordinates, processed, and plotted as EM61 metal response contour maps. Processing included gridding and color contour plotting using Golden Software's Winsurfer program. Individual EM61 profile lines are given in Appendix G.

4.3 EM31 RESULTS

The processed EM31 data are presented as conductivity and inphase contour maps shown in Figures 4.4 and 4.5. These contours have been plotted in color over a detailed base map of the site along with the geophysical grid system to assist in identifying the position of anomalous areas.

4.3.1 UTILITY CORRELATION

Analysis of Figures 4.4 and 4.5 reveal the presence of several characteristic EM features:

a) buried utility lines

b) buildings and other surface structures
c) singular objects such as fire hydrants and other known steel objects (eg, dumpster)
d) anomalies caused by buried materials.

At Site 4, the dominant EM31 contour features are extremely strong readings caused by massive amounts of buried materials. Within this anomaly framework, the water pipeline and gas pipeline (as well as the clubhouse building and sheds) are discernible (Figures 4.4 and 4.5) and agree with base utility maps. Over the raised embankment area, extremely strong EM conductivity and inphase anomalies are very large and cover many acres; they are not the result of buried utilities.

NCBC utility maps show a natural gas pipe running from Seventh Avenue to the Clubhouse, passing immediately west of the golf cart shed. Figures 4.4 and 4.5 reveal a linear anomaly lying along this route, undoubtedly caused by the pipeline. NCBC maps also show a water main running from Seventh Street to the Clubhouse, passing east of the golf cart shed. Due to the dense brush, the southern portion of this area was not surveyed, but from grid line 3250N to 3400N, several pipe-like features are visible in the conductivity and inphase contour maps, confirming the presence of the water pipeline. This line also supplies the fire hydrant at coordinates 3085E/3305N.

Each building, shed, tank, and dumpster is surrounded by a halo of strong positive values. The strong, singular negative anomaly at grid coordinates 2800E/3460N is in response to a large culvert under an unpaved maintenance road. The remaining unexplained anomalies should be considered zones of buried metallic wastes.

4.3.2 BURIED MATERIALS

Inspection of the EM31 contours in Figures 4.4 and 4.5 reveals the presence of massive amounts of buried materials, both metallic and non-metallic, conductive wastes. EM31 conductivities exceed 100 millimhos/meter over large portions of the site, particularly in the areas west of the ninth and putting greens and the vicinity of the Clubhouse. Halos of lesser conductivties exist around these high zones, suggesting that the fill is thinner away from the center or that electrolytes have spread out from a central core of original material. Significant conductivity contours have reached the southwestern portion of the drainage ditch. Pockets of negative conductivity values (characteristic of high concentrations of metal) are evident along the southern and western edges of the southern anomaly. The inphase contours show that the central cores within the main conductivity anomalies also contain appreciable amounts of metal.

A more detailed analysis of Figures 4.4 and 4.5 indicates that the wastes are likely buried in four large pits:

1) The largest conductivity and inphase anomaly is associated with the feature in the southwest portion of the site, west of the putting and ninth greens and immediately east of the drainage ditch. This anomaly covers 1.6 acres, extending between grid lines 2550E to 2900E and between grid lines 3000N and 3350N.

2) The second largest EM31 anomaly surrounds the Clubhouse and parking lot area in the northeastern portion of the site.

3) The third anomaly has a rectangular shape, located west of the Clubhouse, below the Driving Range Tee.

4) The fourth anomaly is much smaller and narrower than the preceding three areas; it is associated with the golf cart shed. During landfilling operations, this area may have served as a ramp to reach the bottom of the large second (Clubhouse) anomaly.

5) Approximately six smaller anomalies lie in the area between the four larger areas described above.

4.4 EM34 RESULTS

The EM34 results for Site 4 are presented in profile form in Figures F-1 and F-2 in Appendix F. Lines 1, 2 and 3 represent the long southwest-northeast profiles west of and parallel to the ditch. Line 4, 5 and 6 represent the southeast-northwest lines acquired perpendicular to the ditch and Lines 1, 2 and 3. Both EM conductivity and inphase measurements are presented together with the conductivity scale (in millimhos/meter) on the left side and the inphase scale (in ppt) on the right side of the plot. Line 4 was placed in the far northwest corner of the site (in the driving range); values obtained in this area should be representative of normal background conditions for this area.

Lines 1 through 6 show that EM34 conductivities lie in the 20-30 millimos/meter range in the fairways west of the drainage ditch. Portions of each profile show evidence of some interference by buried metal pipes used for irrigation of the golf course fairways. Accounting for these distortions in limited portions of the profiles, conductivities in the deeper (10-50) regime are relatively constant over the areas surveyed and are similar to background conditions measured on Line 4. Consequently, no evidence exists for a deeper conductive anomaly (plume) in the 10-50 foot soil/ground water system west of Site 4.

4.5 EM61 RESULTS

4.5.1 CORRELATION TO KNOWN OBJECTS

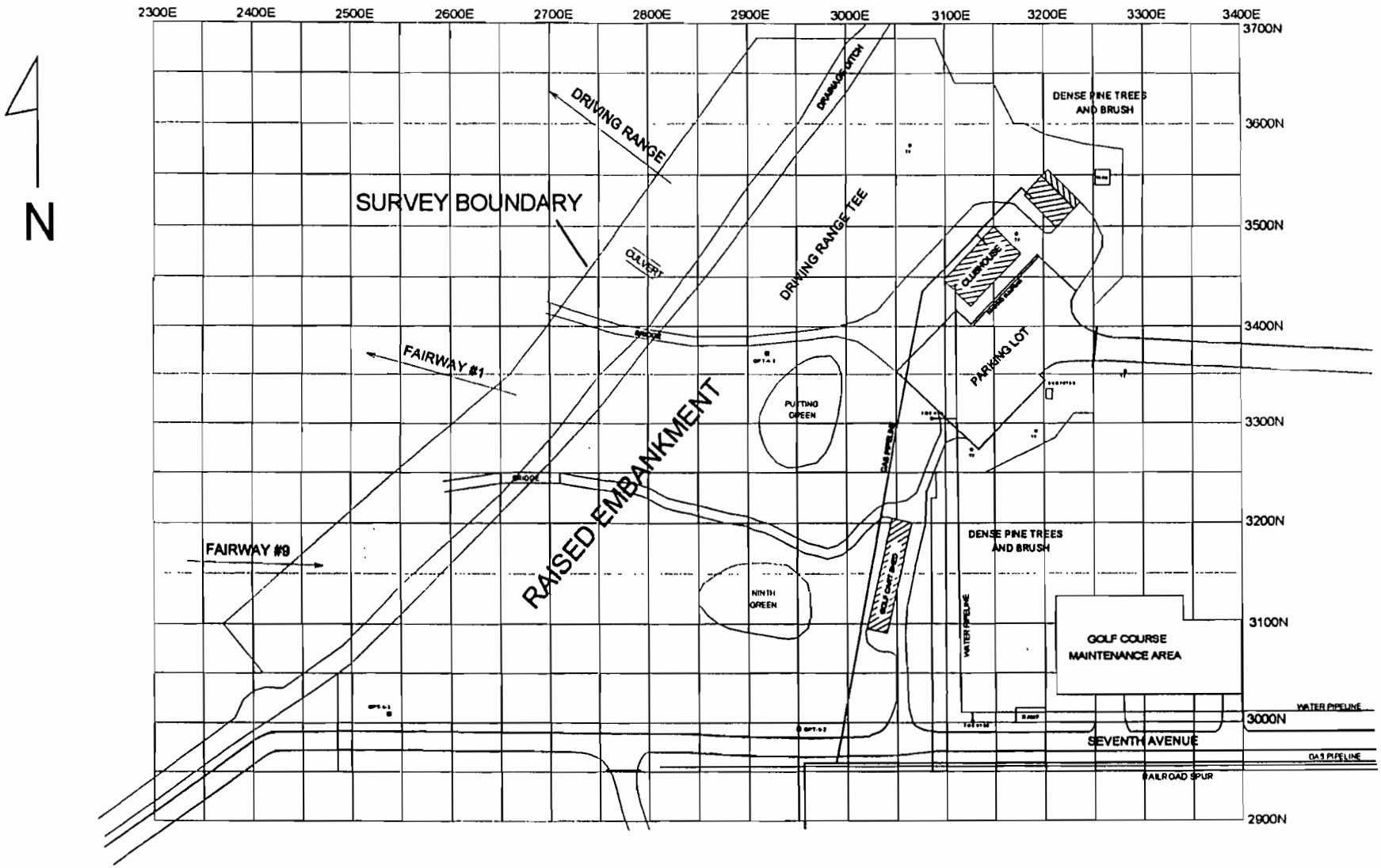
The processed EM61 data are given in Figure 4.6. Analysis of the metal response contours shows a partial correlation with known features observed in the EM conductivity and inphase maps (Figures 4.4 and 4.5). As with the EM31 results, the EM61 contour map is dominated by large areas of high concentrations of buried metal materials. Correlation to the buried gas pipeline is poor in the southern portion of the site; this fact suggests that the pipeline is buried to a depth beyond the range of the instrument. In the northern portion near the Clubhouse, high metal response contours tend to follow the pipeline route. However, because these contour values

are much higher those expected over the pipe (and do not form a regular linear trend), this anomaly is believed to be caused by shallow, scattered metal exhumed during pipeline installation. A similar installation-related trend is observed over the identified water pipe route between grid lines 3250N and 3400N.

4.5.2 BURIED MATERIALS

Inspection of Figure 4.6 reveals that most of the surveyed area is underlain by fill containing high concentrations of metal objects. The area of highest concentration lies along the raised embankment east of the ditch and north of Seventh Avenue in the southwestern corner of the site. Other high concentration areas lie around the Clubhouse and western portion of the paved parking lot, in the driving range tee area, and in the area surrounding the northern part of the golf cart shed. The areas of lowest metal concentration lie in the central portion of the site beneath the ninth green and the southern part of the putting green.

Using EM61 and EM31 data, the outline of the most significant landfilled areas are summarized in the composite EM31 and EM61 anomaly map shown in Figure 4.7. This map identifies four primary and eight secondary zones. The four primary zones (A1 through A4) are large in size and contain the strongest discrete metallic targets. The secondary zones (B1 through B8) contain less intense, discrete anomalies and are much smaller in overall size. The crosses located within each outlined zone define the precise location of the metal target(s) which provided the strongest response in the EM61 instrument. The heavier crosses mark the location of many major metallic targets, whereas the lighter crosses identify only one or two large targets. Possible target depths vary from 1 foot to approximately 15 feet. Future excavation should start at these major target positions within the primary anomaly zones A1 through A4. If drums are uncovered in the primary zones, the secondary target zones (B1 - B8) should also be investigated.

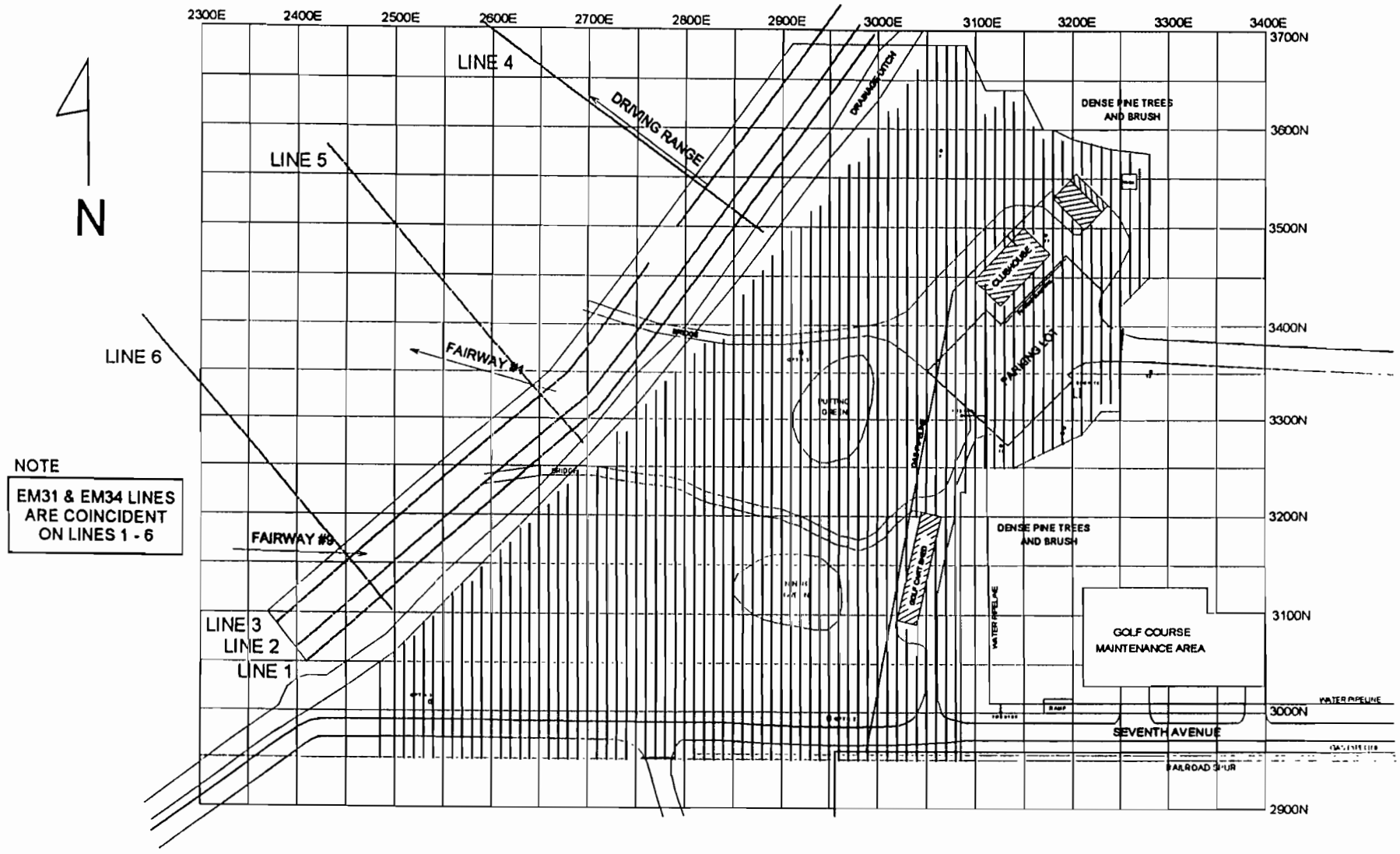


LEGEND

- TELEPHONE POLE
- CULVERT
- MONITOR WELL
- BUILDING

DETAILED SITE MAP	NCBC GULFPORT, MISSISSIPPI
SCALE 0 100 200 FT	GEOPHYSICAL SURVEY OF SITE 4 (GOLF COURSE)
GEOSPHERE MIDWEST 7-28-95	

FIGURE 4.1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3400E
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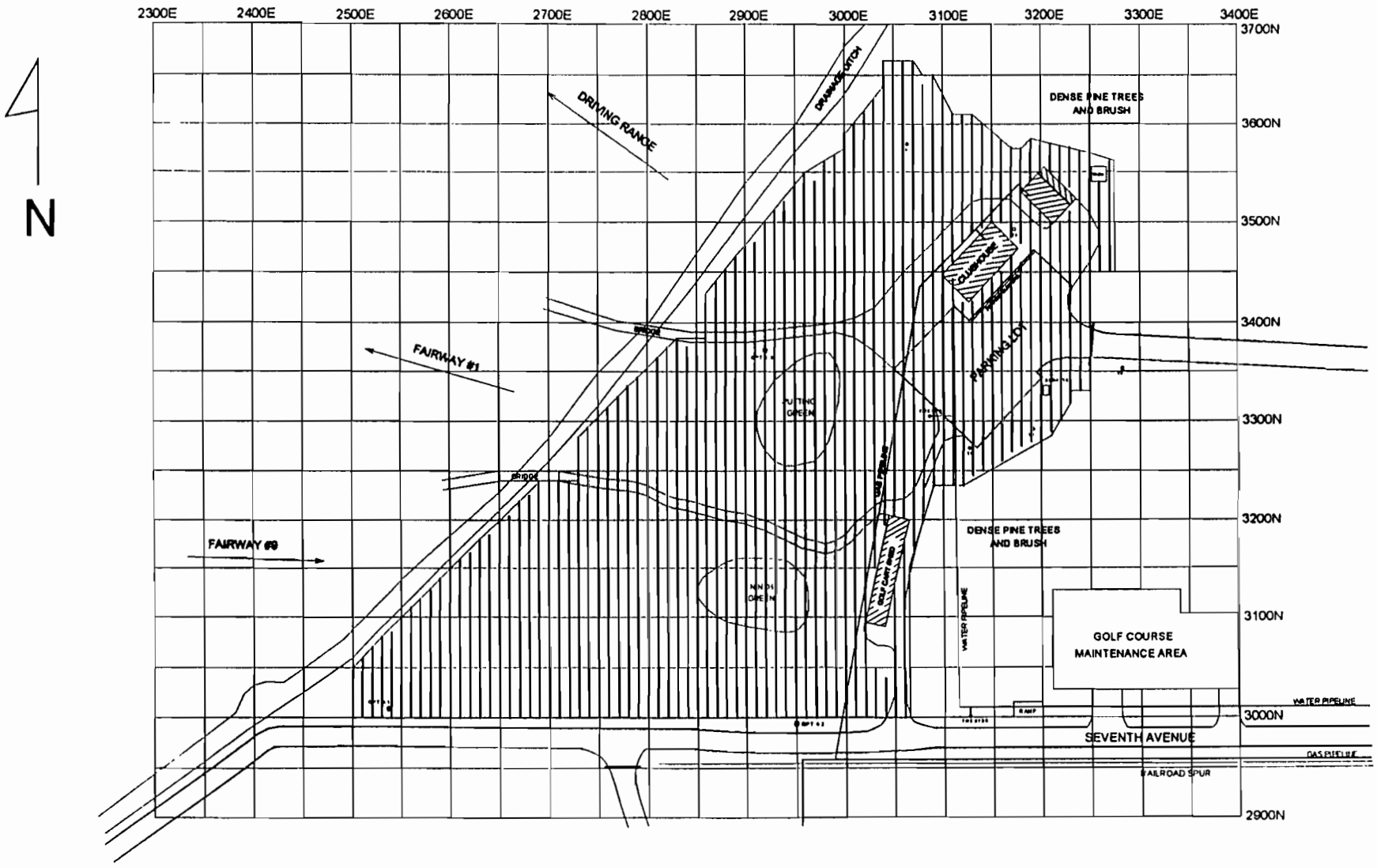
3500N
3400N
3300N
3200N
3100N
3000N
2900N
N
LINE 4
LINE 5
LINE 6
LINE 3
LINE 2
LINE 1
DRIVING RANGE
DRAINAGE DITCH
DENSE PINE TREES AND BRUSH
CLUBHOUSE
PARKING LOT
FAIRWAY #1
FAIRWAY #9
PUTTING GREEN
BRIDGE
OIL PIPELINE
DENSE PINE TREES AND BRUSH
WATER PIPELINE
GOLF COURSE MAINTENANCE AREA
SEVENTH AVENUE
RAILROAD SPUR
NOTE
EM31 & EM34 LINES ARE COINCIDENT ON LINES 1 - 6
LEGEND
TELEPHONE POLE
CULVERT
MONITOR WELL
BUILDING
EM31 & EM34 LINE LOCATIONS
NCBC GULFPORT, MISSISSIPPI
SCALE 0 100 200 FT
GEOSPHERE MIDWEST 7-28-95
GEOPHYSICAL SURVEY OF SITE 4 (GOLF COURSE)

FIGURE 4.2


2300E
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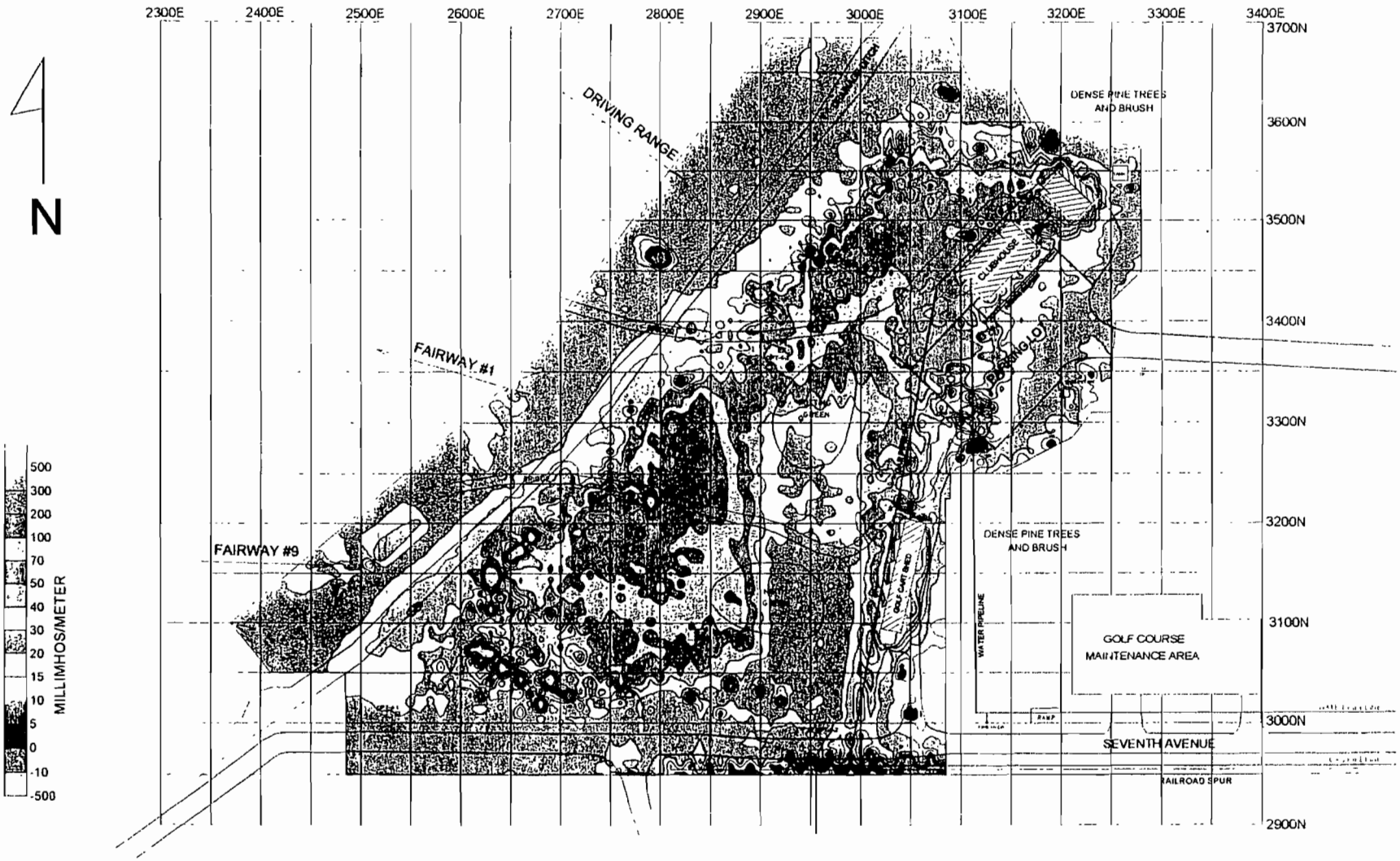
3600N
3500N
3400N
3300N
3200N
3100N
3000N
2900N
N
DRIVING RANGE
DRAINAGE DITCH
DENSE PINE TREES AND BRUSH
CLUBHOUSE
PARKING LOT
FAIRWAY #1
BRIDGE
PUTTING GREEN
FAIRWAY #9
GOLF CART PATH
WATER PIPELINE
DENSE PINE TREES AND BRUSH
GOLF COURSE MAINTENANCE AREA
WATER PIPELINE
SEVENTH AVENUE
GAS PIPELINE
RAILROAD SPUR
LEGEND
TELEPHONE POLE
CULVERT
MONITOR WELL
BUILDING
EM61 LINE LOCATIONS
SCALE
0
100
200 FT
GEOSPHERE MIDWEST
7-28-95
NCBC
GULFPORT, MISSISSIPPI
GEOPHYSICAL SURVEY OF
SITE 4 (GOLF COURSE)

FIGURE 4.3


2300E
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3100E
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3300E
3400E
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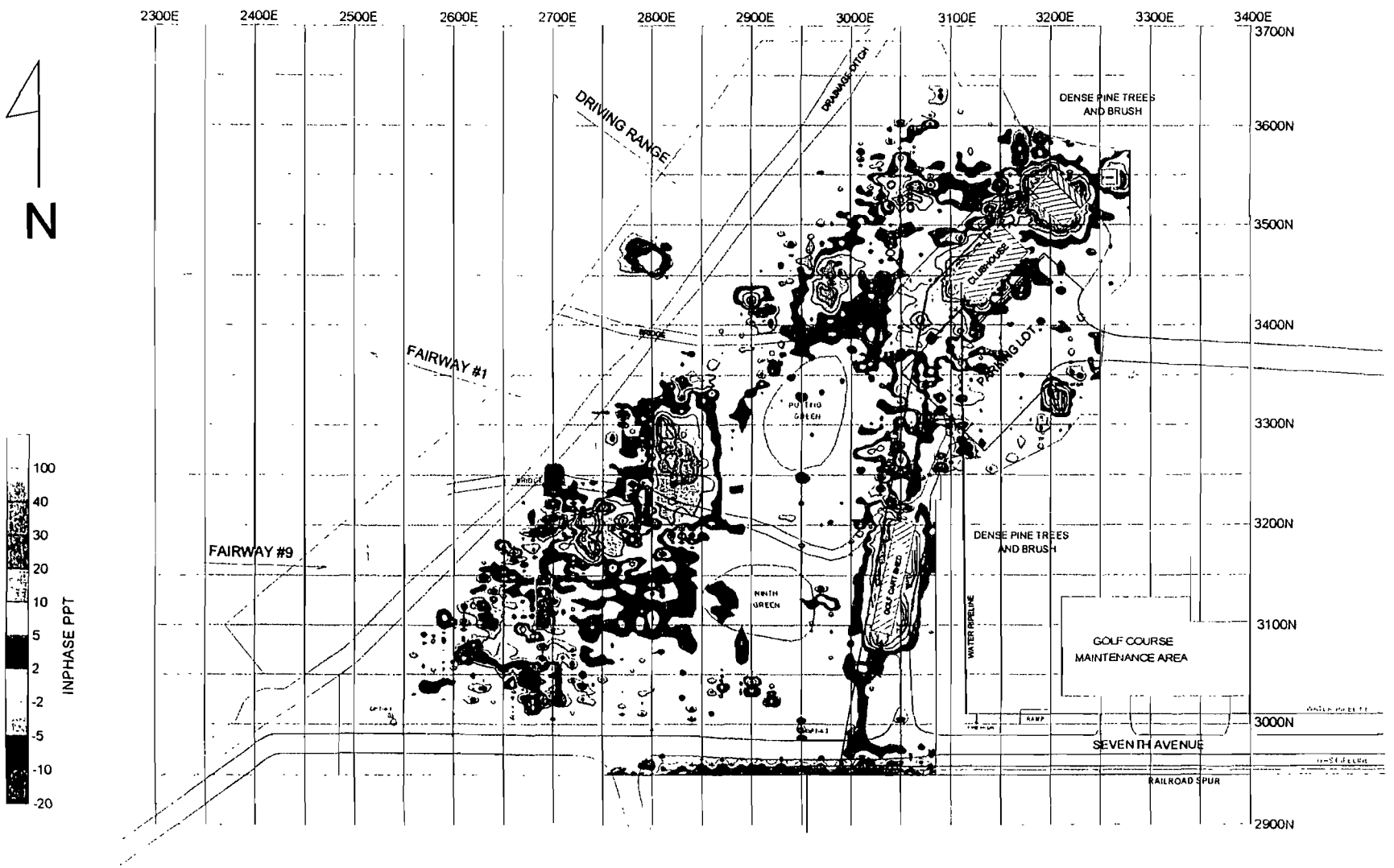
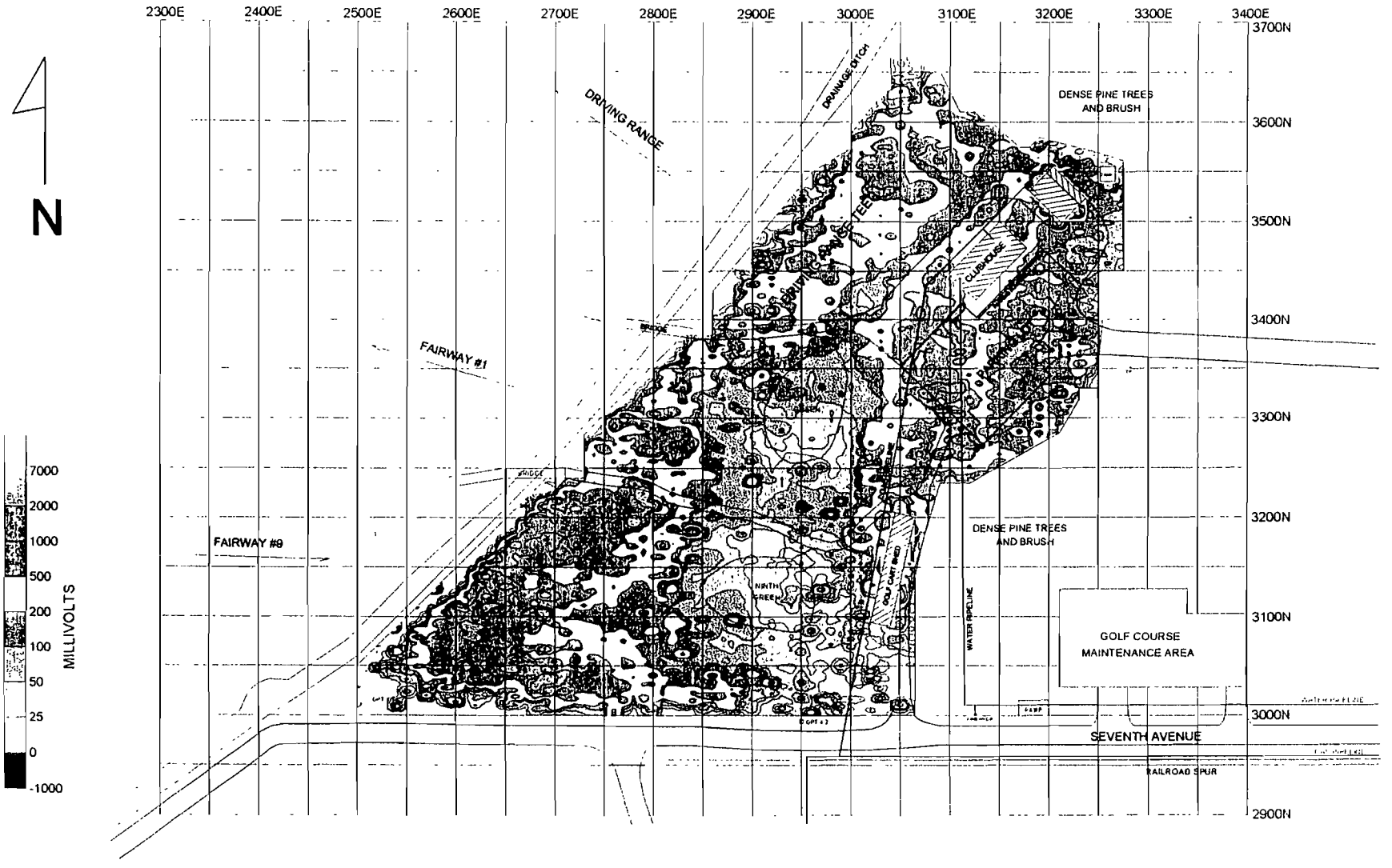
3500N
3400N
3300N
3200N
3100N
3000N
2900N
N
DRIVING RANGE
DENSE PINE TREES AND BRUSH
CLUBHOUSE
FAIRWAY #1
FAIRWAY #9
DENSE PINE TREES AND BRUSH
WATER PIPELINE
GOLF CART PATH
GOLF COURSE MAINTENANCE AREA
SEVENTH AVENUE
RAILROAD SPUR
500
300
200
100
70
50
40
30
20
15
10
5
0
-10
-500
MILLIMHOS/METER
LEGEND
TELEPHONE POLE
CULVERT
MONITOR WELL
BUILDING
EM31 CONDUCTIVITY CONTOUR MAP
NCBC
GULFPORT, MISSISSIPPI
SCALE
0
100
200 FT
GEOSPHERE MIDWEST
7-28-95
GEOPHYSICAL SURVEY OF SITE 4 (GOLF COURSE)

FIGURE 4.4



EM31 INPHASE METAL CONTOUR MAP	NCBC GULFPORT, MISSISSIPPI
SCALE 0 100 200 FT	GEOPHYSICAL SURVEY OF SITE 4 (GOLF COURSE)
GEOSPHERE MIDWEST 7-28-95	

FIGURE 4.5

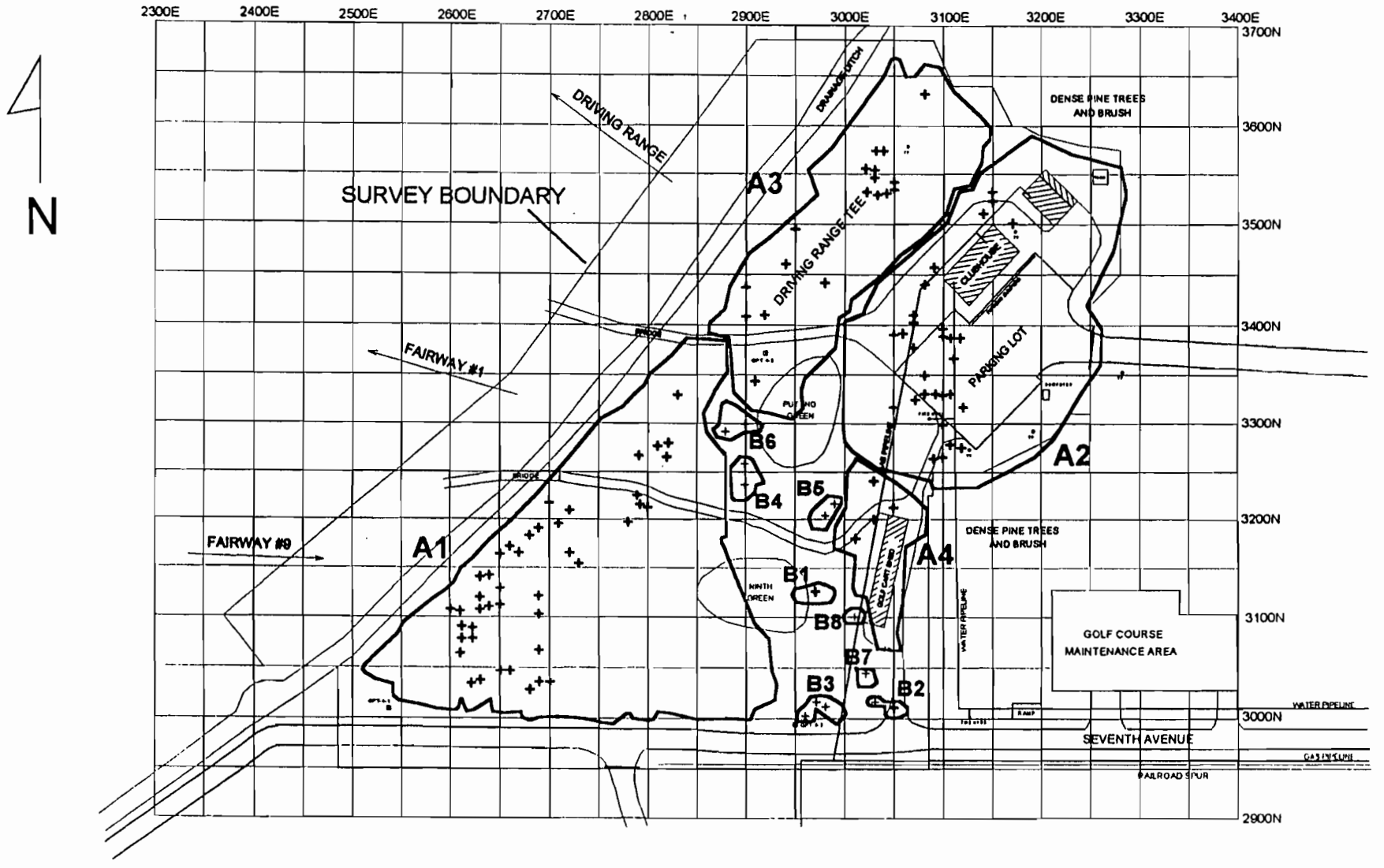


LEGEND

- TELEPHONE POLE
- CULVERT
- MONITOR WELL
- BUILDING

EM61 METAL RESPONSE CONTOUR MAP	NCBC GULFPORT, MISSISSIPPI
SCALE 0 100 200 FT	GEOPHYSICAL SURVEY OF SITE 4 (GOLF COURSE)
GEOSPHERE MIDWEST 7-28-95	

FIGURE 4.6



ANOMALY MAP

- B1 — SECONDARY METAL TARGET AREA
- A1 — PRIMARY METAL TARGET AREA

LEGEND

- TELEPHONE POLE
- CULVERT
- MONITOR WELL
- BUILDING

EM31 & EM61 ANOMALY MAP	NCBC GULFPORT, MISSISSIPPI
SCALE 0 100 200 FT	GEOPHYSICAL SURVEY OF SITE 4 (GOLF COURSE)
GEOSPHERE MIDWEST 7-28-95	

FIGURE 4.7

5 SITE 5: HEAVY EQUIPMENT TRAINING AREA

5.1 SITE DESCRIPTION AND GRID SYSTEM

Site 5 is a large open area used for SeaBee heavy equipment training that includes the use of bulldozers, graders, front loaders, drilling rigs, and cranes. The site occupies approximately 20 acres; the northwest corner of the surveyed area is located 550 feet south of Seventh Street and about 350 feet west of Colby Avenue in the western part of NCBC (Figure 1.1). Site 5 is bounded by a pine forest on the eastern and southwestern sides and a deciduous forest on the western and northwestern sides. A creek defines the site's southern edge. SeaBee heavy equipment is stored along the northern perimeter of the area. Perimeter Road (unpaved) runs across the southwestern corner of the site and crosses the creek over a wooden bridge (Figure 5.1).

Within the survey area, existing structures include three small storage sheds, two groups of steel tanks, and a raised vehicle obstacle course. A large earthen mound 15 feet high and over 400 feet long is oriented east-west across the central section of the site and a low, rounded mound of reworked soil occupies the northwest corner of the site. A 10-foot wide ditch along the site's eastern edge drains runoff to the south over a concrete spillway to the creek. The remainder of the site is flat and non-vegetated.

An earthen ramp, two piles of wooden telephone poles, one erect pole, several coils of steel cable, and an 8-inch steel casing are found in the northern portion of the site. A low concrete wall and several concrete slabs were also encountered on the northwestern edge of Site 5. Four posts and steel cable are found just southeast of the large earthen mound; an old flatbed trailer is parked on the bank above the creek. Two monitor wells (GPT-5-1 and GPT-5-2) are located on the creek bank (Figure 5.1).

A coarse 50x50 foot grid was positioned over the site using wooden stakes and surveyor tape. An east-west base line was established for 1,000 feet along the northern edge of the Site 5 survey area on grid line 2400N. This line was measured from grid line 3000N (in Site 4) along the northern edge of Seventh Street. The north-south base line was constructed by extending the Site 4 grid line 2950E southward 1,500 feet. The physical placement of staked grid nodes extended from easting grid lines 2350E to 3300E and northing lines 1500N to 2450N (and up to 2700N in the northwest corner of the site). Gridding and geophysical field work were conducted at Site 5 during the period 30 June through 18 July 1995.

5.2 GEOPHYSICAL DATA ACQUISITION

5.2.1 EM31

Using the Geonics EM31 instrument, 96 parallel EM lines were made over Site 5 in a north-south direction at a line spacing of 10 feet; two profile lines were also run east-west over the vehicle obstacle course (Figure 5.2). Readings were taken every 2.5 feet along each line except grid lines

2400E through 2760E on which readings were taken every 5 feet (note pattern change in Figure 5.2). Both the quadrature (conductivity) and inphase signals of the instrument were simultaneously recorded on a digital (Omnidata Polycorder) data logger. Where necessary, breaks in the lines were made for unaccessible areas like the earthen mound and sheds. Finally, the data were dumped to a field computer, assigned grid coordinates, processed, and plotted as quadrature conductivity and inphase (metal) contour maps. Processing included gridding and color contour plotting using Golden Software's Winsurfer program. Individual EM31 profile lines are given in Appendix H.

5.2.2 EM34

Due to the lack of interfering utilities and the open accessibility, high density EM34 coverage was made at Site 5. Thirty-eight parallel EM34 lines were run in an east-west direction, at a line spacing of 20 and 50 feet (see Figure 5.3). Readings were taken every 5 feet along each line. Output from the EM34 was recorded on a digital (Omnidata Polycorder) data logger. The data were dumped to a field computer, assigned grid coordinates, processed, and plotted as a series of profile lines. Individual EM34 profile lines are given in Appendix I.

5.2.3 EM61

In-field analysis of preliminary EM31 results indicated that no or very little metallic materials were present in the northern portion of Site 5. Consequently, the Site 5 EM61 survey was conducted in the area south of the 2100N grid line. Sixty-six parallel EM61 lines were run in a north-south direction and 36 lines were made in an east-west direction, all at a line spacing of 10 feet (Figure 5.4). Readings were taken approximately every 1 foot along each line. Data were recorded on a digital (Omnidata Polycorder) data logger. The data were periodically dumped to a field computer, assigned grid coordinates, processed, and plotted as EM61 metal response contour maps. Processing included gridding and color contour plotting using Golden Software's Winsurfer program. Individual EM61 profile lines are given in Appendix J.

5.3 EM31 RESULTS

The processed EM31 data are presented as conductivity and inphase contour maps shown in Figures 5.5 and 5.6. These contours have been plotted in color over a detailed base map of the site along with the geophysical grid system to assist in identifying the position of anomalous areas.

5.3.1 UTILITY CORRELATION

Site maps indicate that buried utilities (such as water pipelines) are not present at Site 5. Figures 5.5 and 5.6 likewise do not show the presence of long thin anomalies associated with pipes. However, both the conductivity and inphase contour maps show many areas of anomalous conditions; several can be correlated to known surface features such as groups of steel tanks, sheds, the flatbed truck trailer, concrete wall, and coils of steel cable. However, most anomalies are caused by unidentified buried metal.

5.3.2 BURIED MATERIAL

EM31 contours in Figures 5.5 and 5.6 reveal the presence of considerable amounts of buried materials, both metallic and some non-metallic materials. Both positive and negative conductivity/inphase contours are scattered in the central, southern and western sectors of the site. EM31 conductivities exceed 100 millimhos/meter in only one small area (2790E/1655N); however, linear patterns of inphase contours (Figure 5.6) suggest that metallic materials may be buried in long trenches both north and south of the earthen mound. In the northern portion of Site 5, small anomalies may be discounted, being associated with the earthen ramp, concrete wall and steel cable occurrences. The anomaly located on the southern side of the four posts feature is caused by surface metal and cable. Slightly elevated EM conductivity values observed between easting grid lines 2800E and 3250E and northing grid lines 2150N and 2400N and centered at coordinates 2600E/2300N are probably caused by SeaBee equipment training activities involving the use of mud pits and fluids during drilling exercises.

In identifying areas of major concern, analysis indicates that landfilling took place in a series of trenches or elongated pits:

1) The largest conductivity and inphase anomaly is centered at coordinates 2760E/1875N (southeast of the steel tanks location). This anomaly is associated with a long group of anomalies and has appearance of a trench approximately 150 feet long and 30 feet wide.

2) A second anomaly lies below Perimeter Road; here a series of conductivity and inphase anomalies define a possible north-south trench 300 feet long and 50 feet wide from grid lines 1475N to 1775N along easting line 2750E.

3) Inphase and conductivity contours north of the earthen mound suggest the presence of 3-4 trenches/pits centered at coordinates 3010E/1920N having overall dimensions of 250x250 feet.

4) Contours south of the earthen mound identify a broad zone of trenches and/or pits lying within a rectangle described by coordinates 2850E/1450N and 3200E/1750N.

5.4 EM34 RESULTS

The EM34 conductivity contours for Site 5 are presented in Figure 5.7. Compared to EM31 results, the longer 10 meter coil spacing of the EM34 acts as an effective "filter" to eliminate anomalies from small and shallow targets. The EM34 conductivity contour map (Figure 5.7) reveals a series of elongated patterns in the areas north and south of the earthen mound. In addition, conductivities within these features are low or negative in value. Such features are interpreted as large, deep burial trenches which contain appreciable amounts of metal. These interpreted trenches complement the EM31 results described above in Section 5.3.2.

Two western trench features (oriented along grid line 2760E) show the strongest (negative) anomalies; thus these two likely contain the greatest concentration of buried metal materials. The large negative anomaly centered at 3050E/1600N may also contain considerable metal debris as may others with relatively low conductivity values (below 10 millimhos/meter). No patterns exist

in the data which might be indicative of a plume associated with these features. The slightly elevated EM34 readings in the northern portion of the site may signify an increase in clay concentrations at depths below 20 feet.

5.5 EM61 RESULTS

5.5.1 CORRELATION TO KNOWN OBJECTS

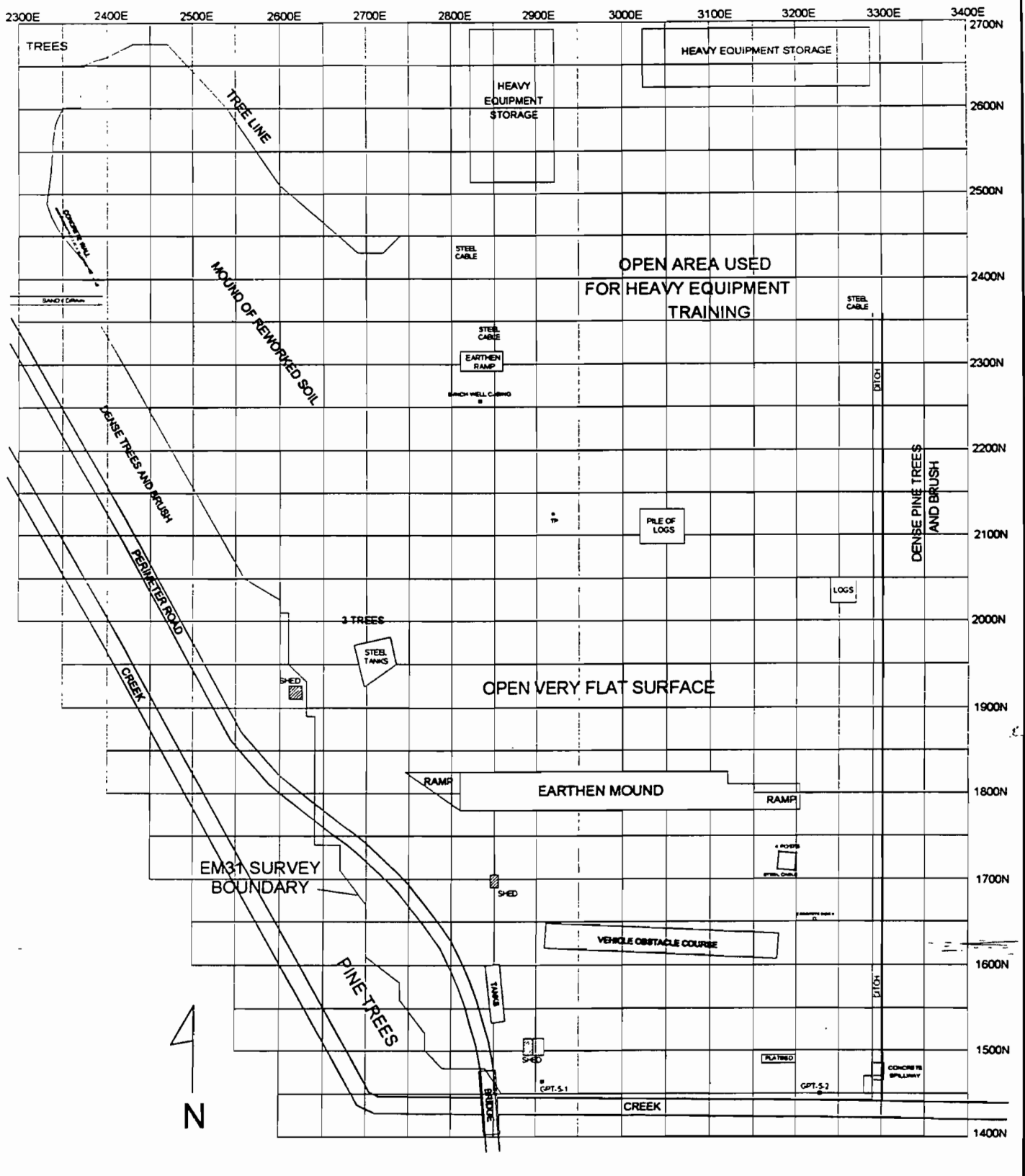
The processed EM61 data are given in Figure 5.8. Because no buried utilities are found at the site, the EM61 contours can be directly compared to known metallic surface features. These include two sheds, two groups of tanks, 4 posts and associated cable, and the flatbed trailer. The remaining EM61 anomalies may then be considered representative of buried metals.

5.5.2 BURIED MATERIALS

Inspection of Figure 5.8 reveals that large portions of the area immediately north and south of the earthen mound contain very large quantities of metal fill. The fill extends approximately 600 feet in a north-south direction from grid line 2050N in the north to the creek's northern bank in the south; in the east-west direction, it extends some 550 feet from grid line 2650E to 3200E. Based upon the distribution of contour patterns visible in Figure 5.8, distinctive trench-like features can be defined (similar to trends observed in the EM31 and EM34 contours). The most significant EM61 anomalies are found in the trench-like feature situated subparallel to grid line 2760E at 1900N. Other important metal concentrations are found at 2925E/1880N, 3040E/1850N, 3050E/1975N, and 3150E/1845N in the area north of the earthen mound. In the area south of the mound high concentrations are found at 3040E/1700N, 3080E/1590N, 3060E/1580N, 3025E/1535N, 2995E/1540N, 2980E/1510N, 2925E/1590N, 2945E/1750N, 2875E/1670N, and 2790E/1755N.

Using the EM61, EM31 and EM34 contour maps, the outline of the most significant landfilled areas are summarized in the composite anomaly map shown in Figure 5.9. This map identifies 11 primary trenches and elongated pits of considerable size; 13 secondary pits are also delineated. In addition, a third classification identifies 10 zones which contain isolated large metal targets.

The primary zones (A1 through A11) have dimensions that vary from 30x100 feet to 60x320 feet; they contain the strongest and largest discrete metallic anomalies. The secondary zones' (B1 through B13) dimensions vary from 10x20 to 50x100 feet; they contain less intense, discrete anomalies of smaller lateral extent. Isolated metal target zones (C1 through C10) occupy less than a 10x10 foot area. The crosses located within each outlined zone define the precise location of the metal target(s) which provided the strongest response in the EM61/EM31 instruments. The heavier crosses mark the location of several major metallic targets, whereas the lighter crosses identify one or two large targets. Possible target depths vary from 1 foot to approximately 15 feet. Future excavation should start at these major target positions within the primary anomaly zones A1 through A11. If drums are uncovered in the primary zones, the secondary target zones (B1 - B13) should also be investigated. The likelihood of the C1-C10 targets representing intact drums is very low.



LEGEND

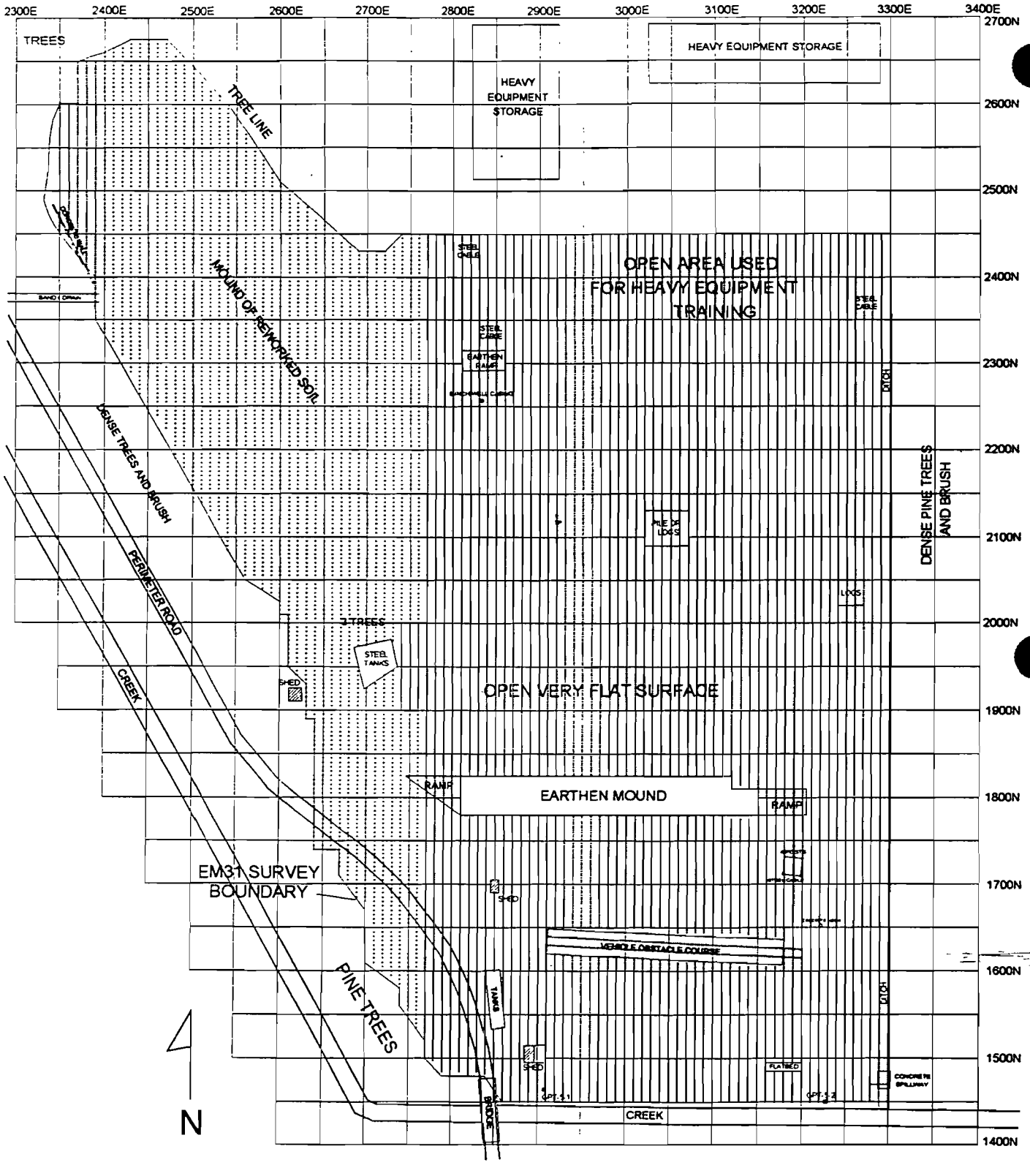
TP TELEPHONE POLE

GPT 5 1 MONITOR WELL

BUILDING/SHED

DETAILED SITE MAP	NCBC GULFPORT, MISSISSIPPI
SCALE 0 100 200 FT	GEOPHYSICAL SURVEY OF SITE 5 (EQUIPMENT TRAINING)
GEOSPHERE MIDWEST 7-28-95	

FIGURE 5.1



LEGEND

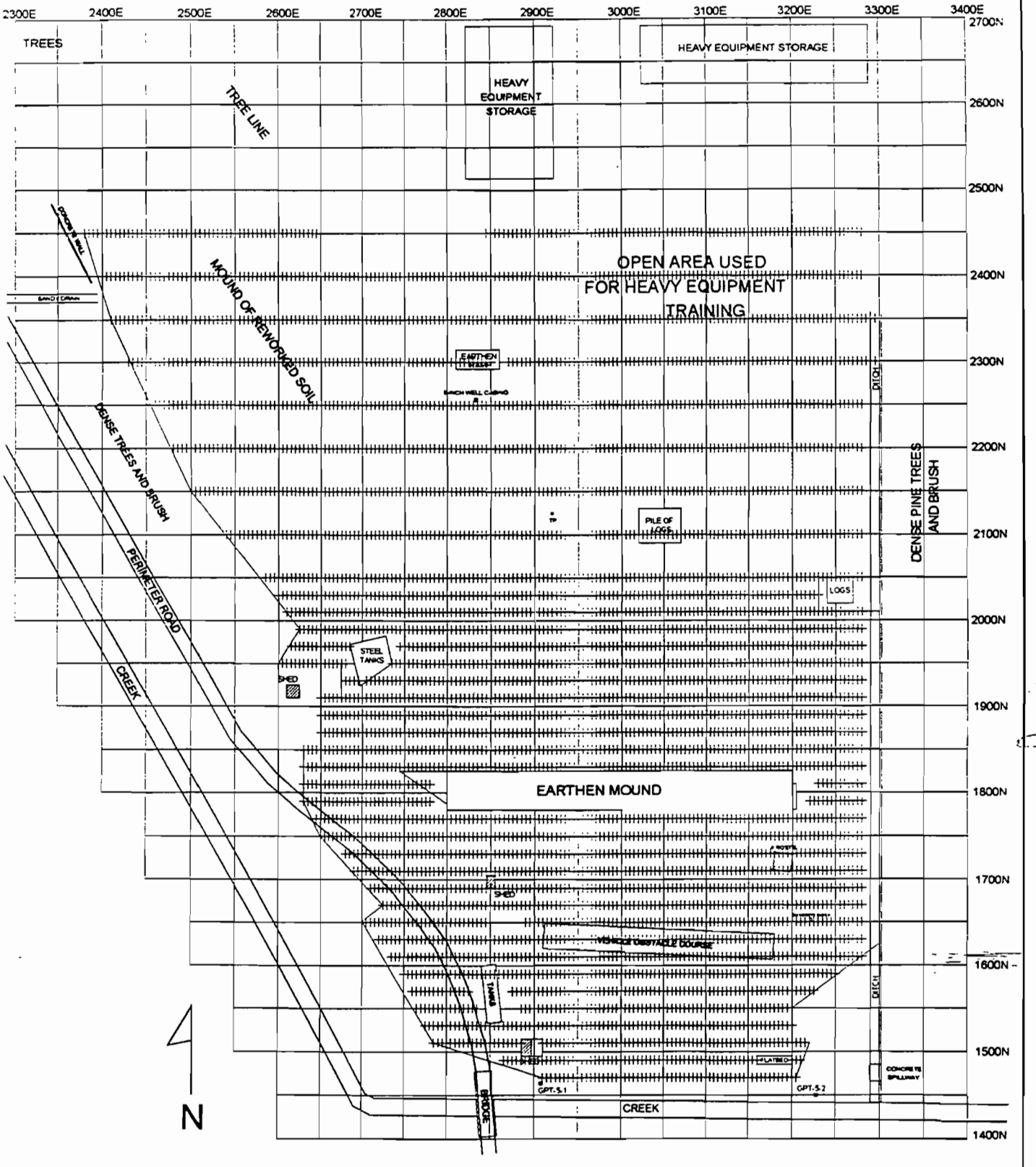
TELEPHONE POLE

MONITOR WELL

BUILDING/SHED

EM31 LINE LOCATIONS	NCBC GULFPORT, MISSISSIPPI
SCALE 0 100 200 FT	GEOPHYSICAL SURVEY OF SITE 5 (EQUIPMENT TRAINING)
GEOSPHERE MIDWEST 7-26-95	

FIGURE 5.2

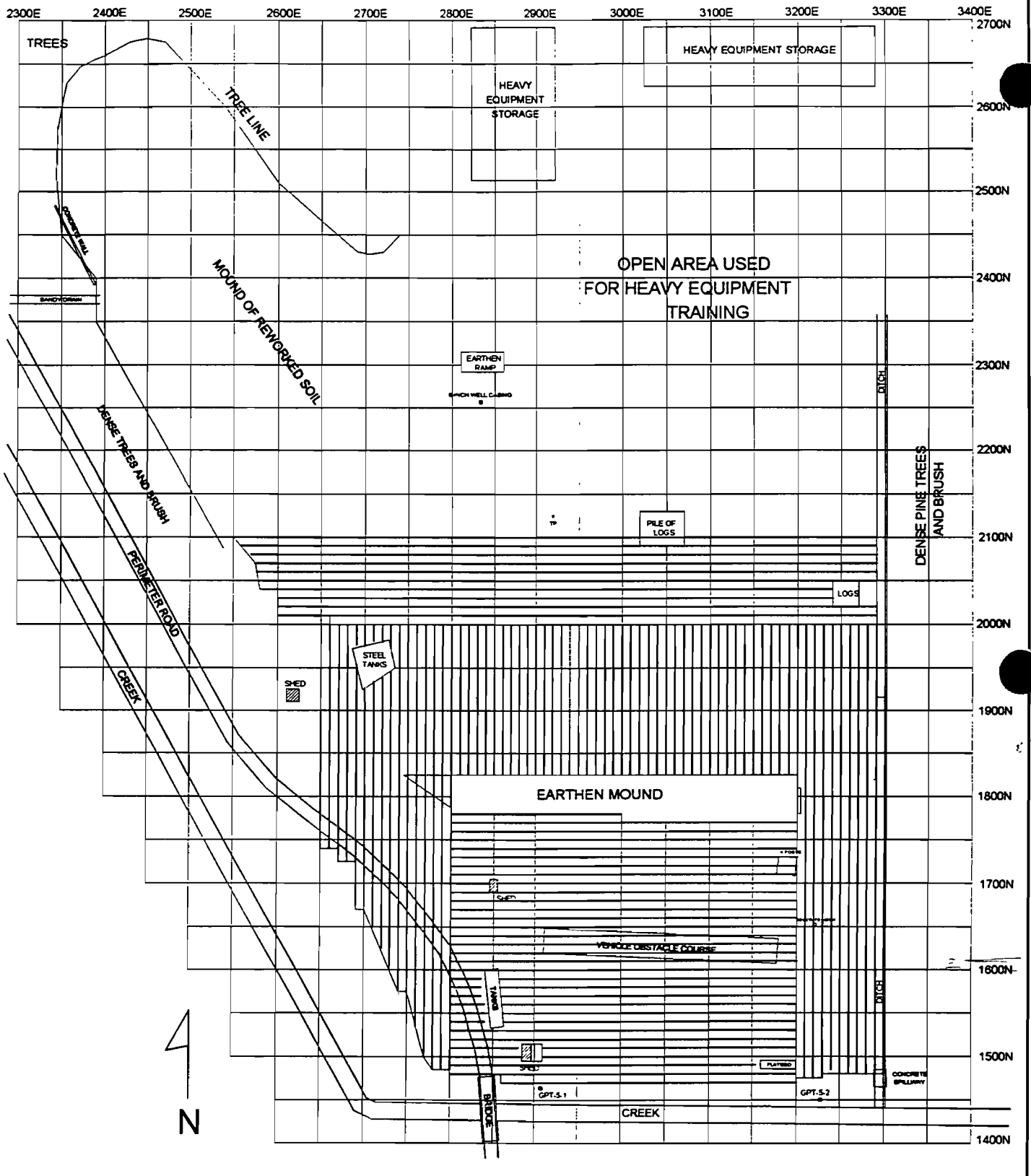


LEGEND

o TP	TELEPHONE POLE
□ GPT 5 1	MONITOR WELL
	BUILDING/SHED

EM34 LINE LOCATIONS	NCBC GULFPORT, MISSISSIPPI
SCALE 0 100 200 FT	GEOPHYSICAL SURVEY OF SITE 5 (EQUIPMENT TRAINING)
GEOSPHERE MIDWEST 7-28-95	

FIGURE 5.3

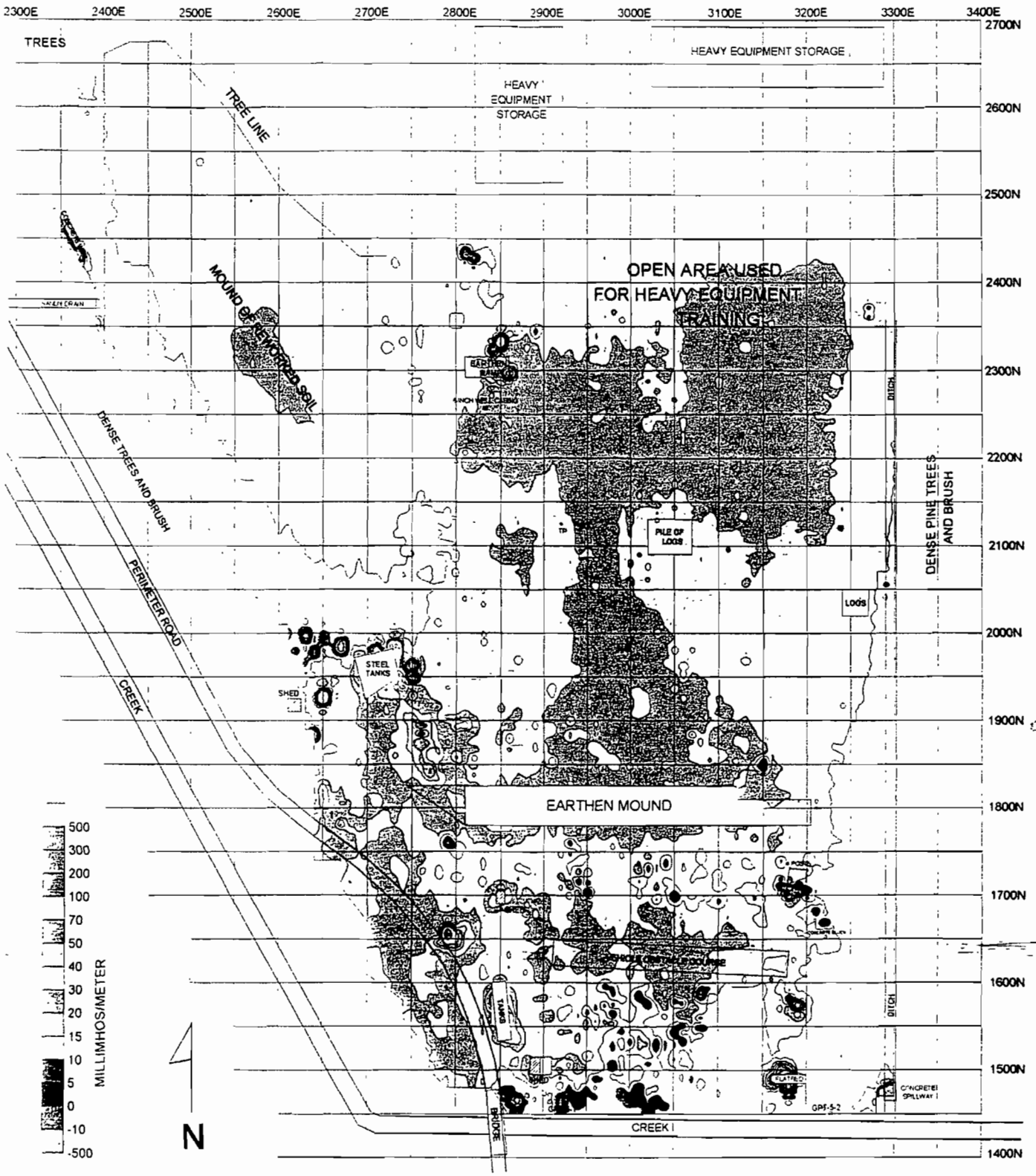


LEGEND

o TP	TELEPHONE POLE
GPT 5-1	MONITOR WELL
	BUILDING/SHED

EM61 LINE LOCATIONS	NCBC GULFPORT, MISSISSIPPI
SCALE 0 100 200 FT	GEOPHYSICAL SURVEY OF SITE 5 (EQUIPMENT TRAINING)
GEOSPHERE MIDWEST 7-31-95	

FIGURE 5.4


2300E
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2800E
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3100E
3200E
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3400E
2700N
2600N
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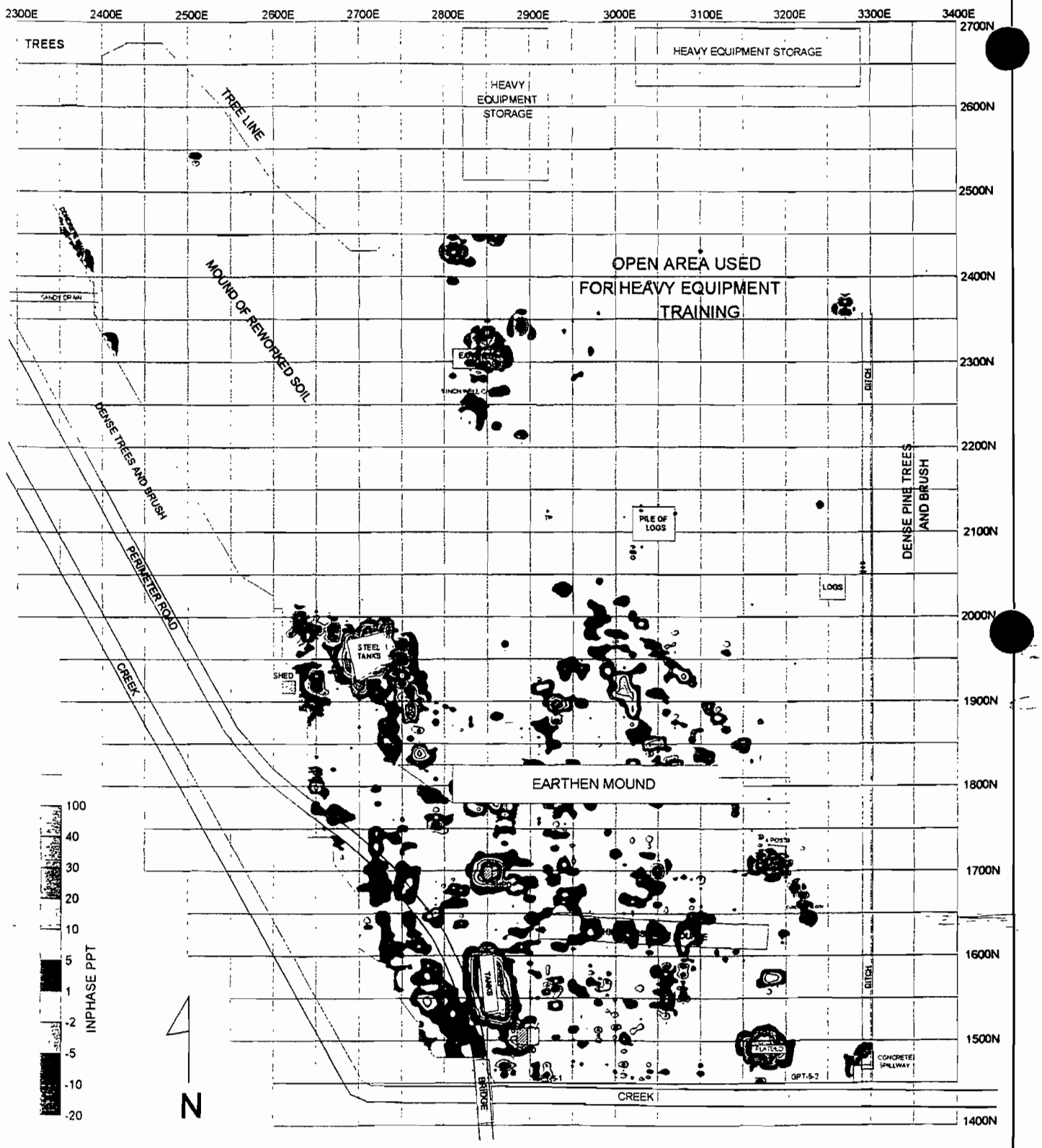
2400N
2300N
2200N
2100N
2000N
1900N
1800N
1700N
1600N
1500N
1400N
TREES
HEAVY EQUIPMENT STORAGE
HEAVY EQUIPMENT STORAGE
TREE LINE
OPEN AREA USED FOR HEAVY EQUIPMENT TRAINING
MOUND OF REMOVED SOIL
DENSE TREES AND BRUSH
PERIMETER ROAD
CREEK
DENSE PINE TREES AND BRUSH
DITCH
PILE OF LOGS
LOGS
STEEL TANKS
SHED
EARTHEN MOUND
TANKS
BRIDGE
CREEK
GPT-5-2
500
300
200
100
70
50
40
30
20
15
10
5
0
-10
-500
MILLIMHOS/METER
N
LEGEND
TP TELEPHONE POLE
GPT-5-1 MONITOR WELL
BUILDING/SHED
EM31 CONDUCTIVITY CONTOUR MAP
NCBC
GULFPORT, MISSISSIPPI
SCALE 0 100 200 FT
GEOSPHERE MIDWEST
7-28-95
GEOPHYSICAL SURVEY OF SITE 5 (EQUIPMENT TRAINING)

FIGURE 5.5


2300E
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2600N
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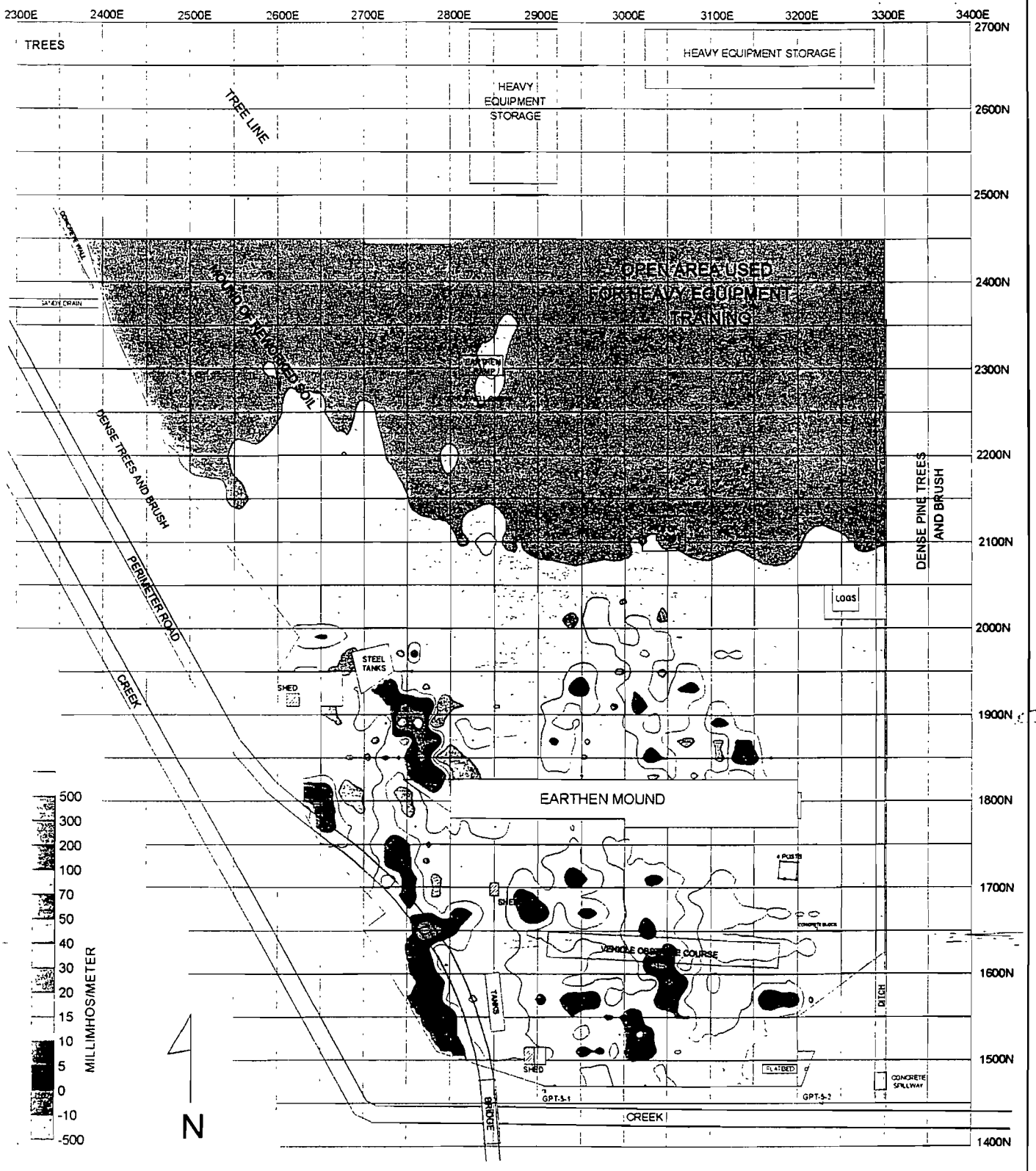
2200N
2100N
2000N
1900N
1800N
1700N
1600N
1500N
1400N
TREES
TREE LINE
HEAVY EQUIPMENT STORAGE
HEAVY EQUIPMENT STORAGE
OPEN AREA USED FOR HEAVY EQUIPMENT TRAINING
MOUND OF REWORKED SOIL
SANDY DRAIN
DENSE TREES AND BRUSH
PERIMETER ROAD
CREEK
DITCH
DENSE PINE TREES AND BRUSH
PILE OF LOGS
LOGS
STEEL TANKS
SHED
EARTHEN MOUND
POSTS
BRIDGE
CONCRETE SPILLWAY
GPT-S-2
CREEK
100
40
30
20
10
5
1
-2
-5
-10
-20
INPHASE PPT
N
LEGEND
TP TELEPHONE POLE
GPT-S-1 MONITOR WELL
BUILDING/SHED
EM31 INPHASE METAL CONTOUR MAP
NCBC
GULFPORT, MISSISSIPPI
SCALE 0 100 200 FT
GEOSPHERE MIDWEST 7-28-95
GEOPHYSICAL SURVEY OF SITE 5 (EQUIPMENT TRAINING)

FIGURE 5.6

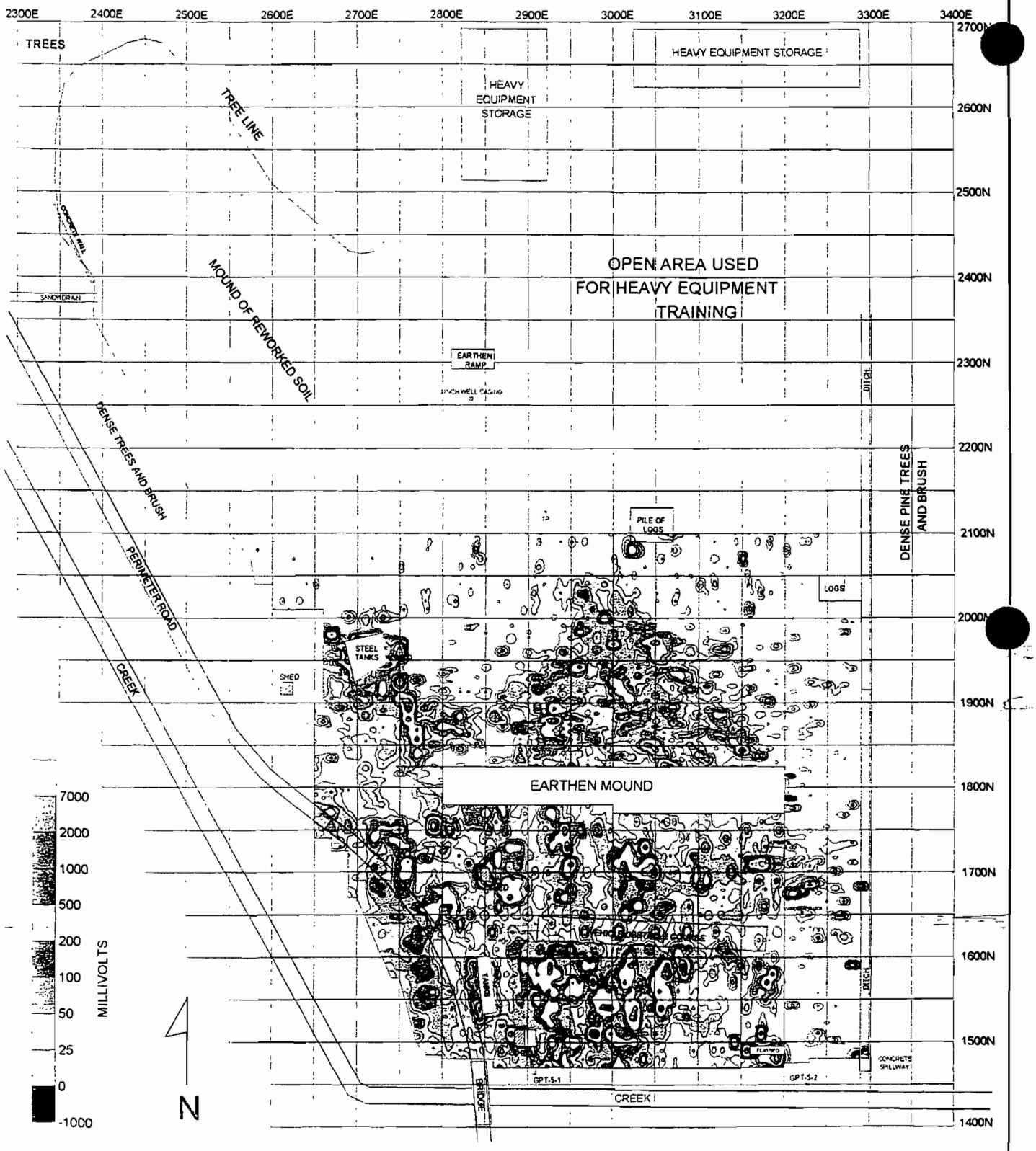


LEGEND

TP	TELEPHONE POLE
GPT-5-1	MONITOR WELL
	BUILDING/SHED

EM34 CONDUCTIVITY CONTOUR MAP	NCBC GULFPORT, MISSISSIPPI
SCALE 0 100 200 FT	GEOPHYSICAL SURVEY OF SITE 5 (EQUIPMENT TRAINING)
GEOSPHERE MIDWEST 7-28-95	

FIGURE 5.7



LEGEND

TP	TELEPHONE POLE
GPT-5-1	MONITOR WELL
	BUILDING/SHED

EM61 METAL RESPONSE CONTOUR MAP	NCBC GULFPORT, MISSISSIPPI
SCALE 0 100 200 FT	GEOPHYSICAL SURVEY OF SITE 5 (EQUIPMENT TRAINING)
GEOSPHERE MIDWEST 7-31-95	

FIGURE 5.8

APPENDIX A

DESCRIPTION OF GEOPHYSICAL METHODS

APPENDICES

APPENDIX A A-1
DESCRIPTION OF GEOPHYSICAL METHODS

APPENDIX B B-1
SITE 1: EM31 PROFILE DATA

APPENDIX C C-1
SITE 1: EM34 PROFILE DATA

APPENDIX D D-1
SITE 1: EM61 PROFILE DATA

APPENDIX E E-1
SITE 4: EM31 PROFILE DATA

APPENDIX F F-1
SITE 4: EM34 PROFILE DATA

APPENDIX G G-1
SITE 4: EM61 PROFILE DATA

APPENDIX H H-1
SITE 5: EM31 PROFILE DATA

APPENDIX I I-1
SITE 5: EM34 PROFILE DATA

APPENDIX J J-1
SITE 5: EM61 PROFILE DATA

APPENDIX K K-1
FIELD INFORMATION

Electrical Methods

Electrical properties are among the most useful geophysical parameters in characterizing earth materials. Variations in electrical conductivity (or its inverse, resistivity) typically correlate with variations in water saturation, fluid conductivity, porosity, permeability, and the presence of metal. Depending on the particular site, these variations may be used to locate contaminant plumes, salt water intrusion, stratigraphic units, sinkholes, fractures, buried drums and tanks, and any other feature whose electrical properties contrast with the surrounding earth.

Ground conductivity can be measured either directly, using the galvanic resistivity method, or inductively, using electromagnetic induction (EM). Because EM requires no direct contact with the ground surface, data can be acquired more quickly than with resistivity. Resistivity, however, can provide better vertical resolution and is generally less sensitive to cultural noise such as fences, buildings and overhead powerlines.

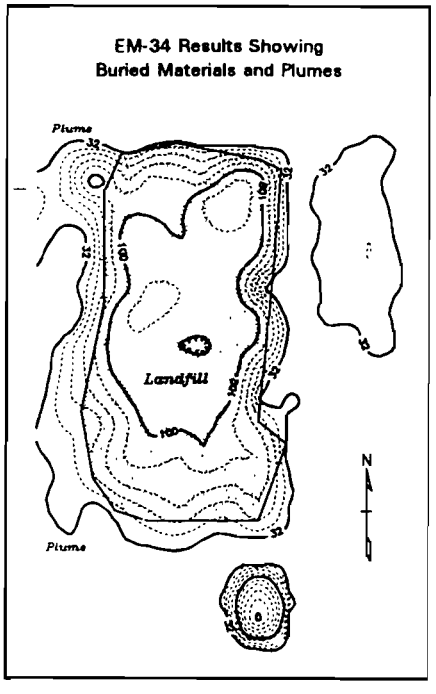
Applications of Electrical Methods

EM and resistivity can be applied to a wide variety of problems encountered in environmental, ground water, geotechnical, and archaeological work, including:

- **Location of buried drums, tanks, trenches, and utilities**
- **Location of landfills and bulk buried materials**
- **Delineation of contaminant plumes**
- **Depth of water table and aquifer identification and mapping**
- **Continuity of stratigraphic interfaces such as clay layers**
- **Mapping of faults and fractures**
- **Location of karst features**

Electromagnetic Induction

The EM technique measures the electrical properties of materials contained in the subsurface including soil, rock, ground water, and any buried objects. An alternating current in the EM transmitter coil creates a magnetic field which induces electrical current loops within the ground; the current loops, in turn, create a secondary magnetic field. Both the primary magnetic field (produced by the transmitter coil) and the secondary field induce a corresponding alternating current in the EM receiver coil. After compensating for the primary field (which can be computed from the relative positions and orientations of the coils), both the magnitude and relative phase of the secondary field can be measured. These can be converted to components in-phase and 90° out of phase with the transmitted field. The out of phase (or quadrature-phase) component, using certain simplifying assumptions, can be converted to a measure of apparent ground conductivity. The in-phase component, while generally not responsive to changes in bulk conductivity, is especially responsive to discrete, highly-conductive bodies such as metal objects. The apparent conductivity measurement is the average conductivity of one or more layers in the ground in the proximity of the instrument, to a depth of investigation dependent on the coil spacing, orientation, operating frequency of the instrument, and the individual conductivity of each ground layer.



EM-34 Results Showing Buried Materials and Plumes

Galvanic Resistivity

Using an older technique called resistivity, electrical conductivity (resistivity) can also be measured by applying a current directly into the ground through a pair of electrodes. A voltage difference measured across a second electrode pair provides the necessary information to calculate the apparent earth resistivity (the inverse of apparent conductivity). The depth of investigation depends on the electrode separation and geometry, with greater electrode separations yielding bulk resistivity measurements to greater depths.

The EM and resistivity methods are used in two different modes: **profiling** and **sounding**. Profiling is used to detect lateral variations across a site by taking a series of readings along a line using a fixed configuration of coils or electrodes. (EM is typically used in the profile mode). Soundings are used to estimate vertical variations in electrical conductivity or resistivity. A resistivity sounding is made by taking many readings with increasing electrode separations at a single location. An EM sounding is obtained by taking readings at a single location with several coil spacings and coil orientations. The data are then inverted to produce a model of conductivity (resistivity) variations with depth. Due to the greater number of readings possible, resisitivity soundings provide better vertical resolution than EM soundings. Profiles and soundings may be obtained simultaneously to yield a 3-dimensional model.

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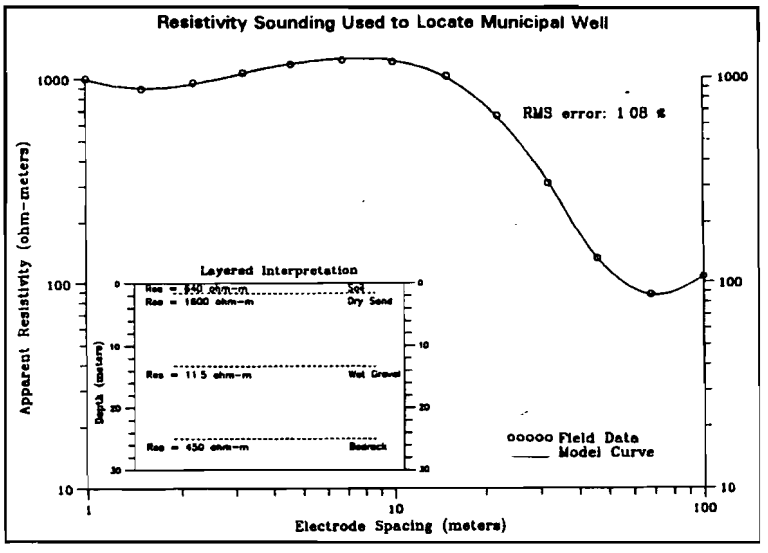


While both EM and resistivity measure apparent ground conductivity, their response to certain kinds of anomalies differs markedly. EM is very sensitive to highly conductive media, so a thin, high conductivity layer may dominate over much thicker, low conductivity layers. Also, if conductivities are very high, the measurements become non-linear and eventually turn negative. The resistivity method is less sensitive to thin, high conductivity layers and can measure even the lowest and highest apparent conductivities.

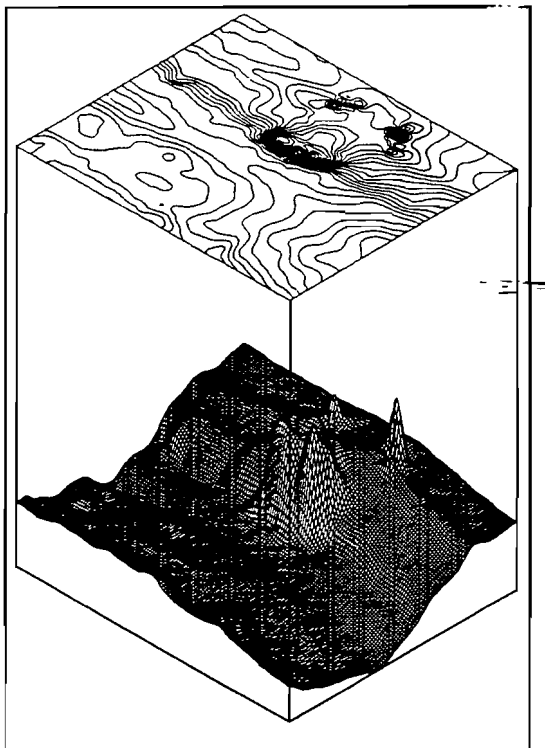
Field Procedures

For EM work, Geosphere uses the Geonics EM-31DL, EM-34XL, and EM-38 instruments. All instruments read apparent conductivity directly in units of millimhos/meter. The one-man portable EM-31 has a fixed coil separation with an investigative depth of 20 feet. The EM-34 requires a crew of two and has three coil separations, with investigative depths from 25 to 200 feet. Geosphere has rigged a 4x4 truck to acquire continuous data over large areas using the 10 meter configuration; this method has proved valuable in locating and mapping deep karst features, faults, and buried sand channels. The EM-38 measures shallow soil conductivities to depths of 3 to 6 feet. With all three instruments, data are acquired either on analog strip charts or digitally which are downloaded to a field computer. The in-phase component of these EM systems also provide valuable data concerning the location of buried metal objects and pipes. Other EM systems available include the EM-39 borehole induction logger.

Resistivity surveys usually employ a Wenner electrode array (four co-linear, equally-spaced electrodes) and an ABEM Terrameter earth resistivity meter. The instrument reading in ohms (applied current divided into the measured voltage difference) is converted to apparent resistivity (in ohm-meters) by means of a geometric factor determined for the electrode array. For soundings, the inter-electrode spacings are varied approximately logarithmically (six readings per decade) over a range determined for the particular site.

Data Processing

Conductivity profile data are often computer gridded, producing a data set which can be contoured or displayed as a 3-dimensional surface. Resistivity sounding data are inverted, using in-house computer software, producing a model of discrete layers, each of constant resistivity (or conductivity). The inversion routine computes theoretical curves based on a trial model and adjusts the model parameters iteratively until it achieves a satisfactory match with the field data. Geologic interpretation of electrical conductivity data involves matching observed anomalies with characteristic responses to known features. Constraining information, such as well data, outcrops, or other geophysical data, is very useful in producing a comprehensive, coordinated interpretation.



EM-31 Data Showing 3D Surface Display

Summary

Electrical geophysical techniques are extremely useful in a wide variety of situations. For example, the EM method can quickly provide very high density information which cannot otherwise be obtained in critical areas. Geosphere is among the leaders nationwide in applying electrical methods to environmental investigations, hazardous waste sites, ground water exploration, karst features, archaeology, and other disciplines.

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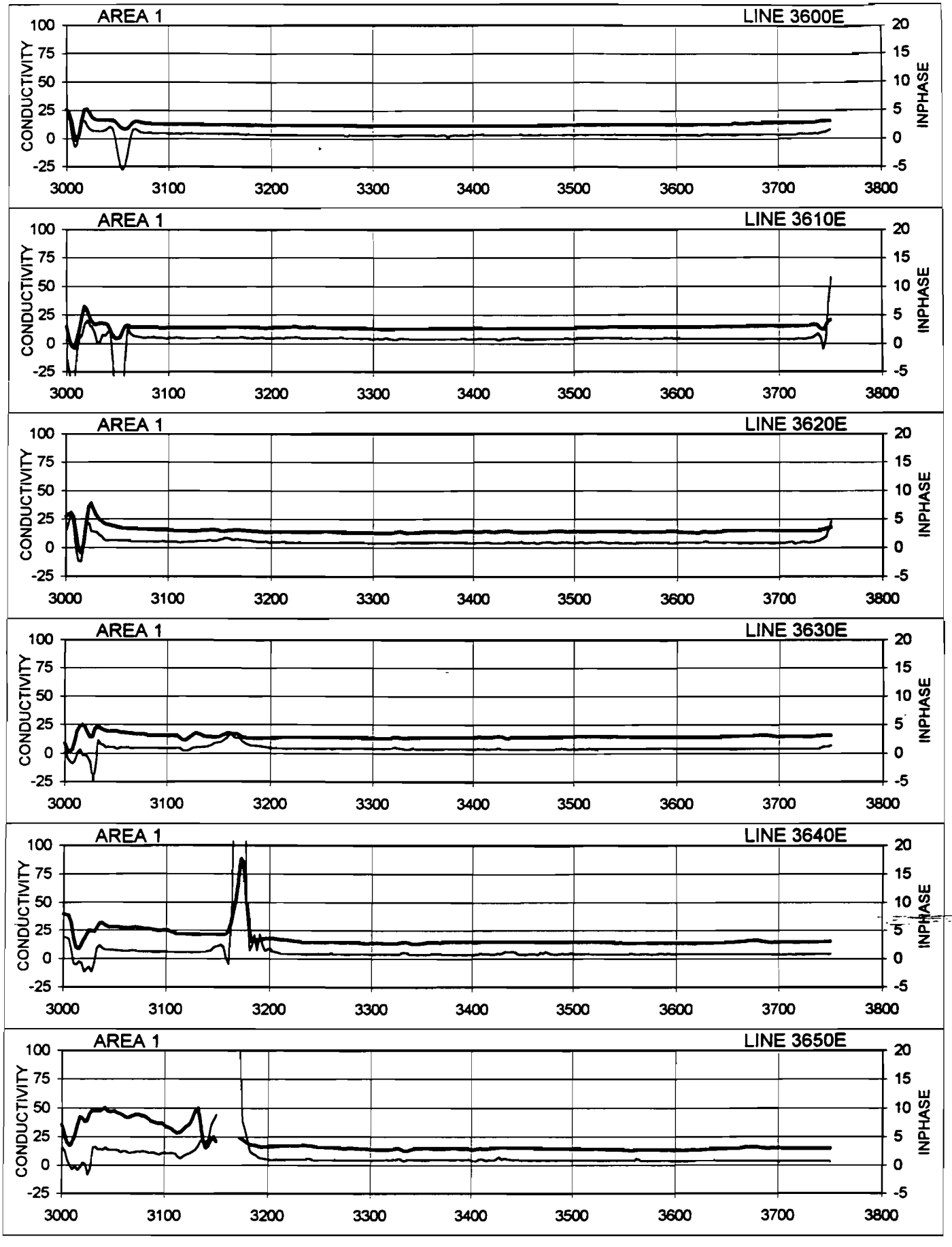
APPENDIX B

SITE 1: EM31 PROFILE DATA

This appendix is a compilation of all EM31 profile data obtained at Site 1. Locations of these EM lines are given in Figure 3.2. The following profiles include line number (easting coordinate), conductivity and inphase (vertical) scales and station location labels (northing coordinates). Conductivity values are given in millimhos/meter (mmhos/m), inphase values are given in parts per thousand (ppt) and location coordinates are in feet.

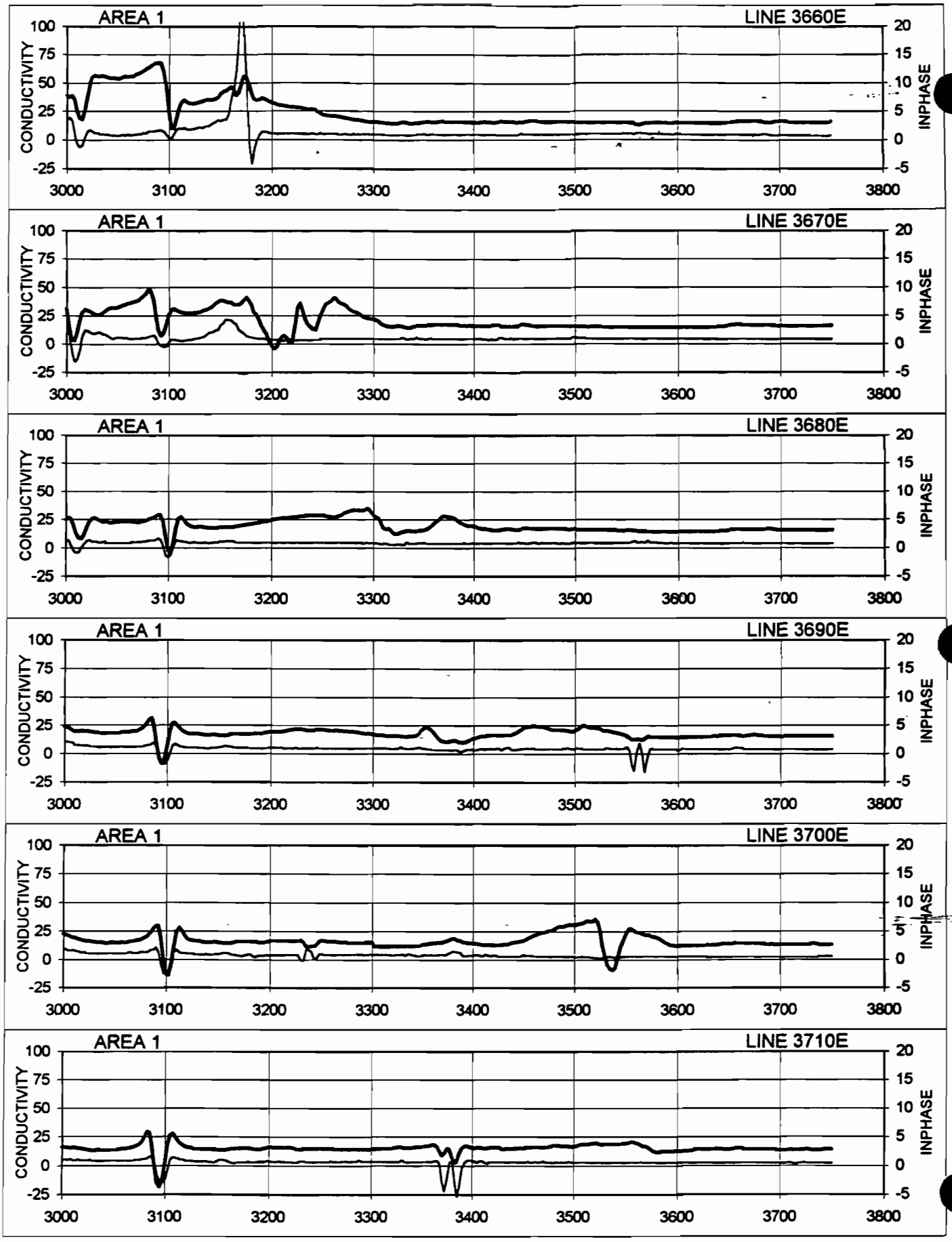
B1. EM31 SURVEY: N-S PROFILES FROM SITE 1

Figures B-1 to B-21.



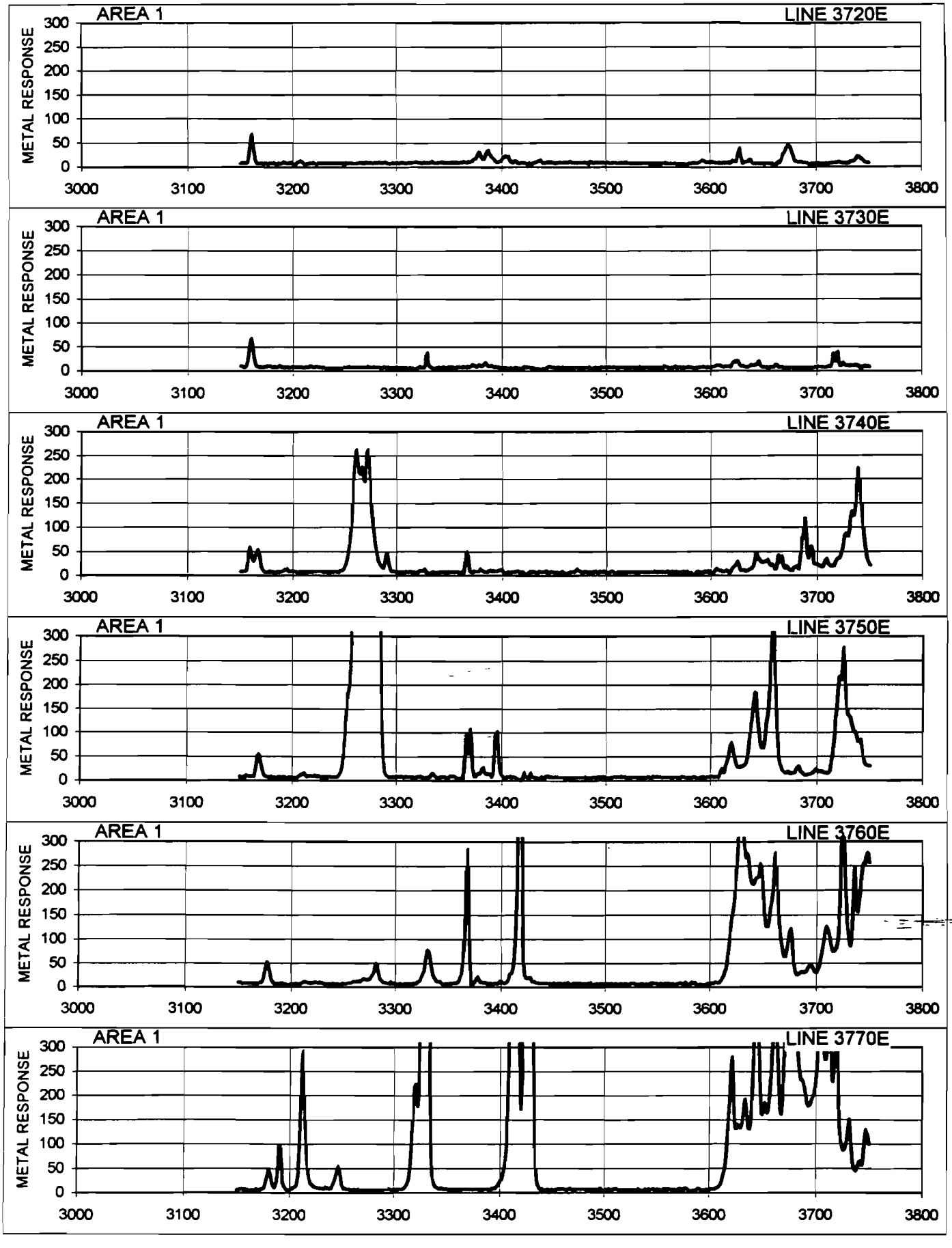
GEOSPHERE MIDWEST

FIGURE B-1



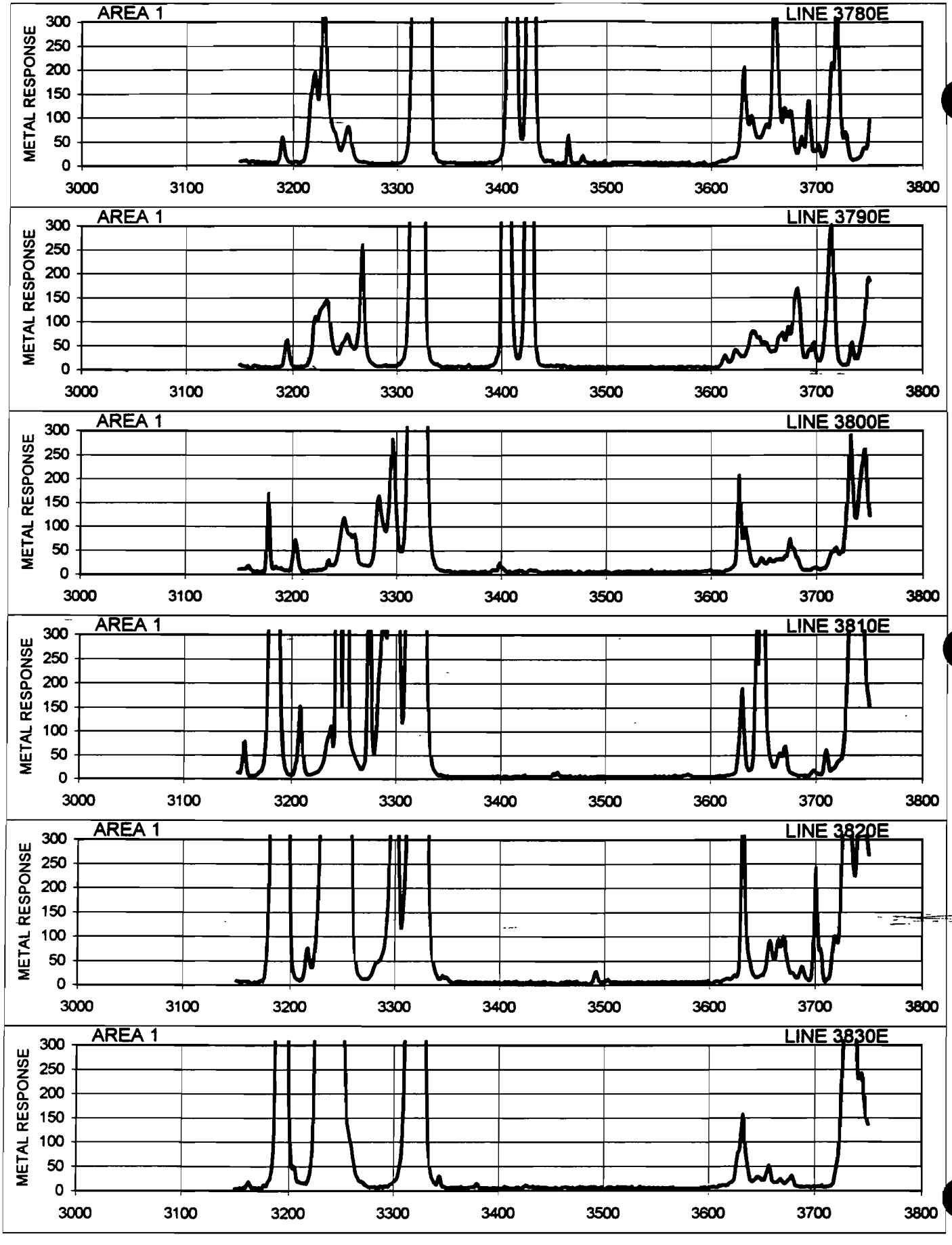
GEOSPHERE MIDWEST

FIGURE B-2



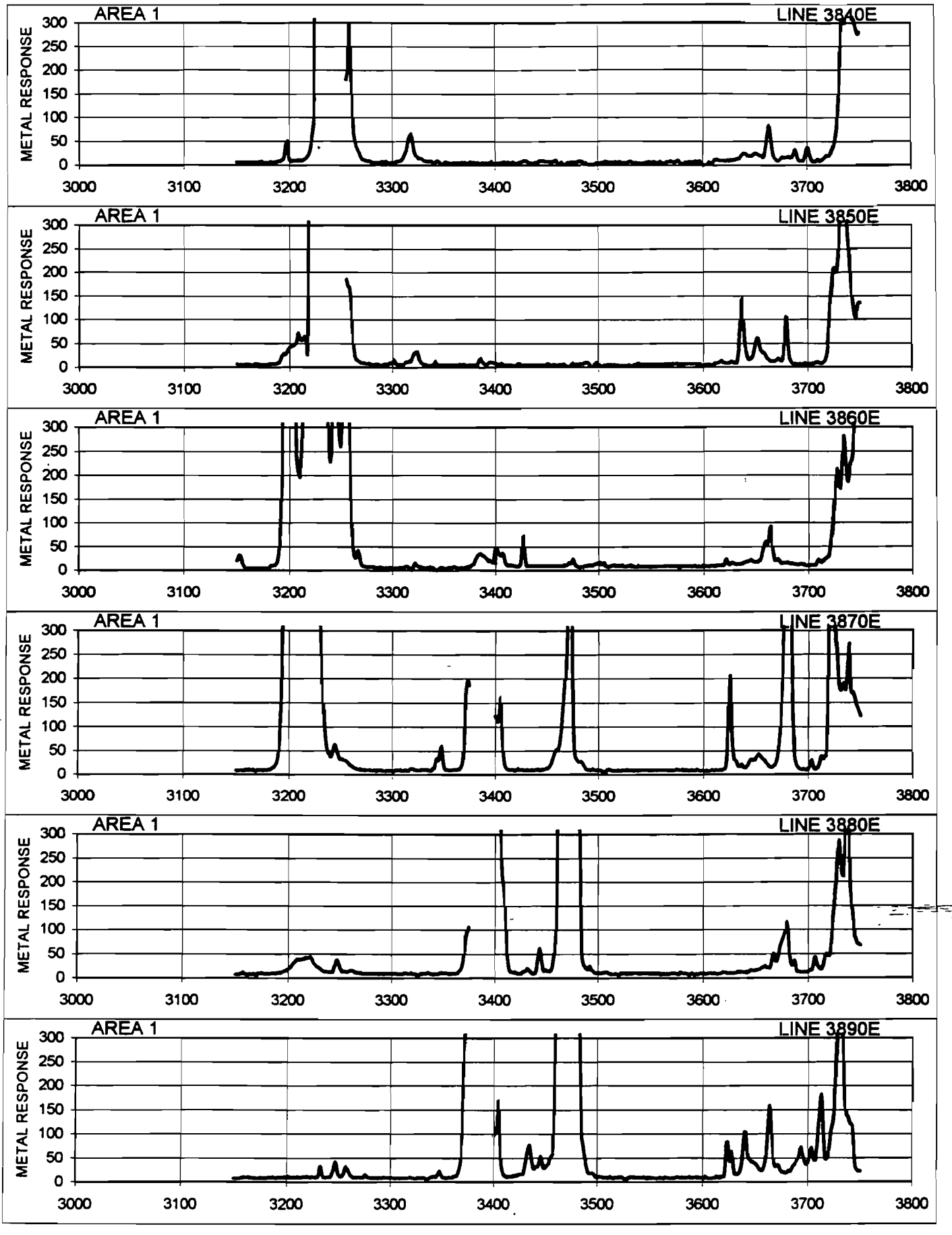
GEOSPHERE MIDWEST

FIGURE D-3



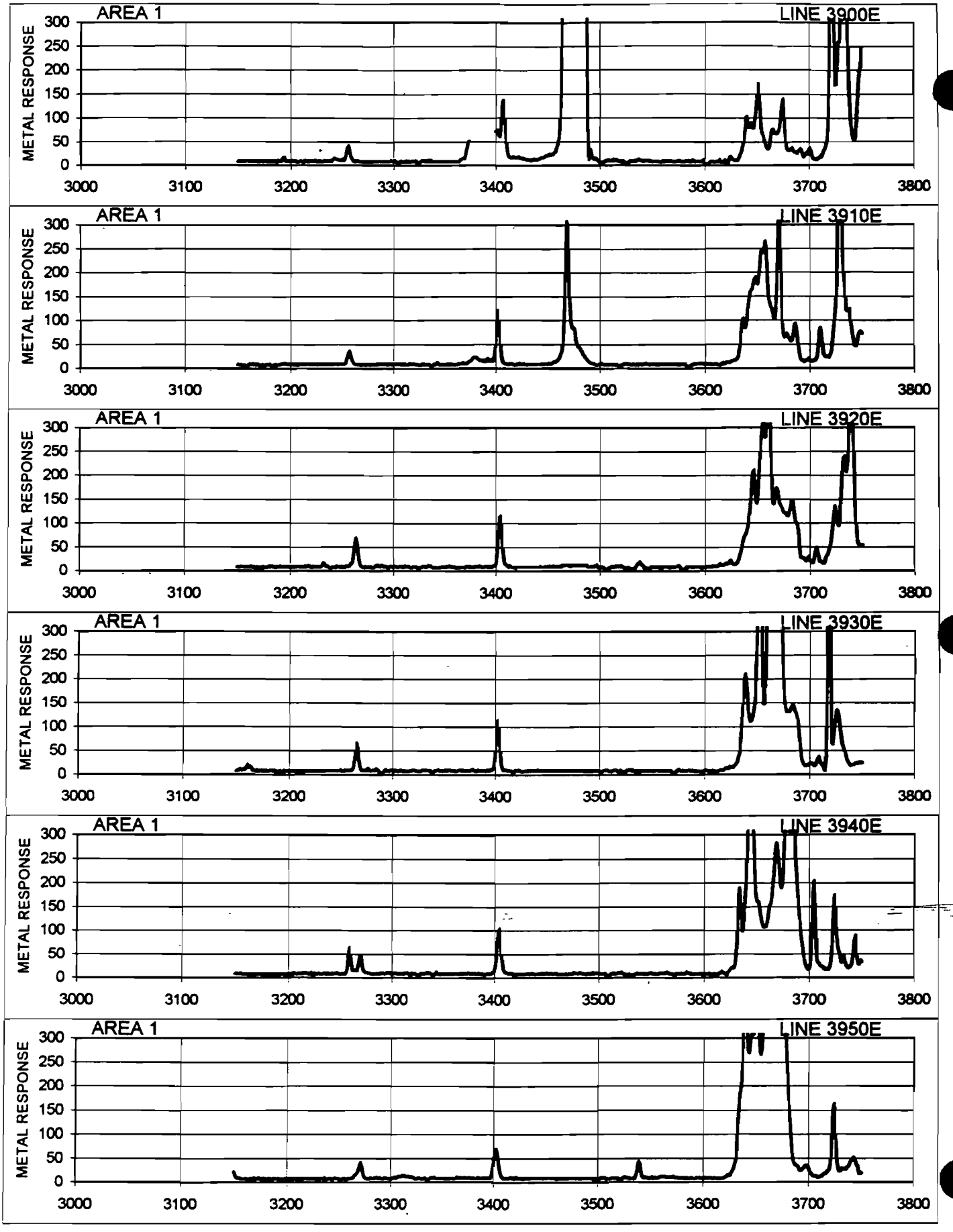
GEOSPHERE MIDWEST

FIGURE D-4



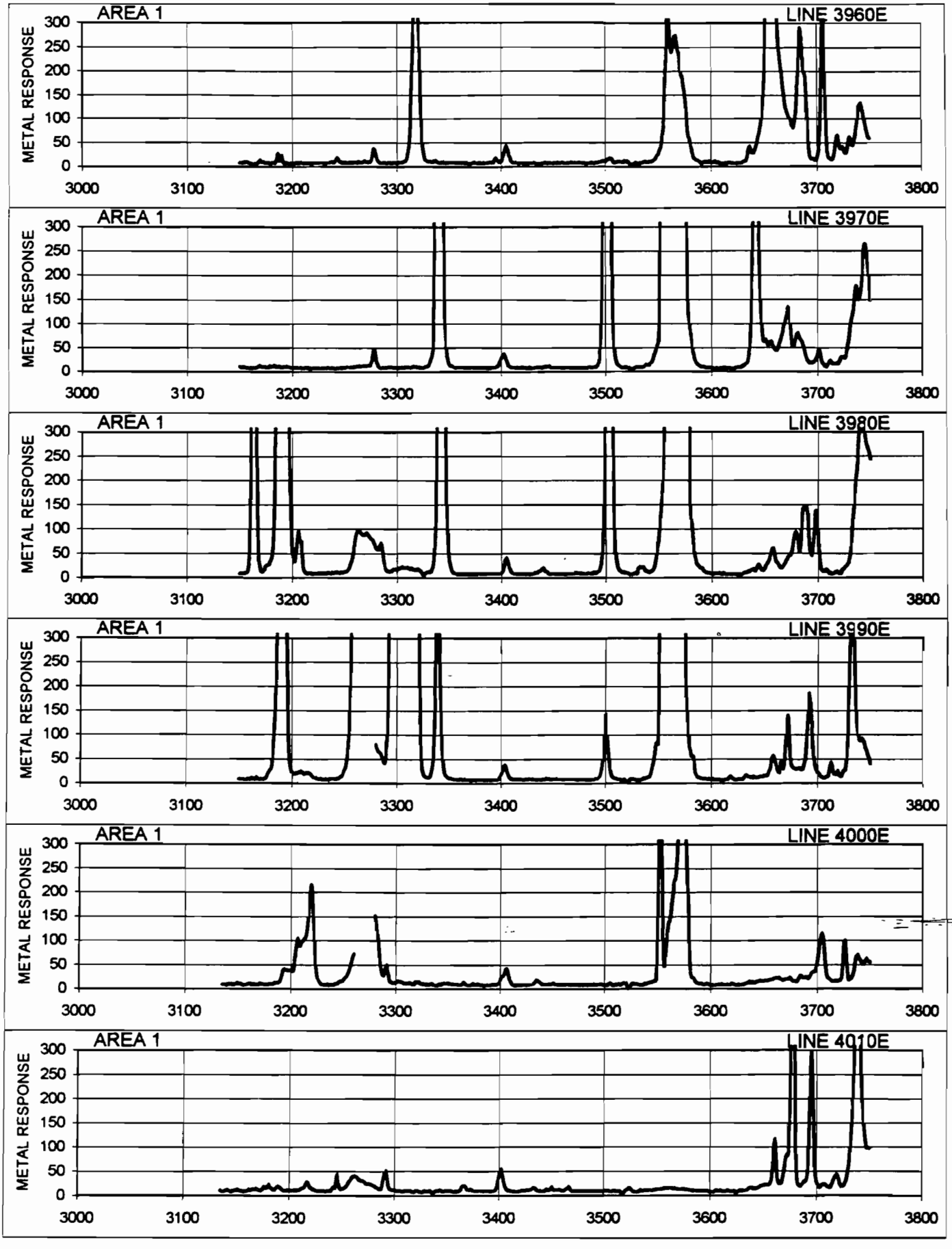
GEOSPHERE MIDWEST

FIGURE D-5



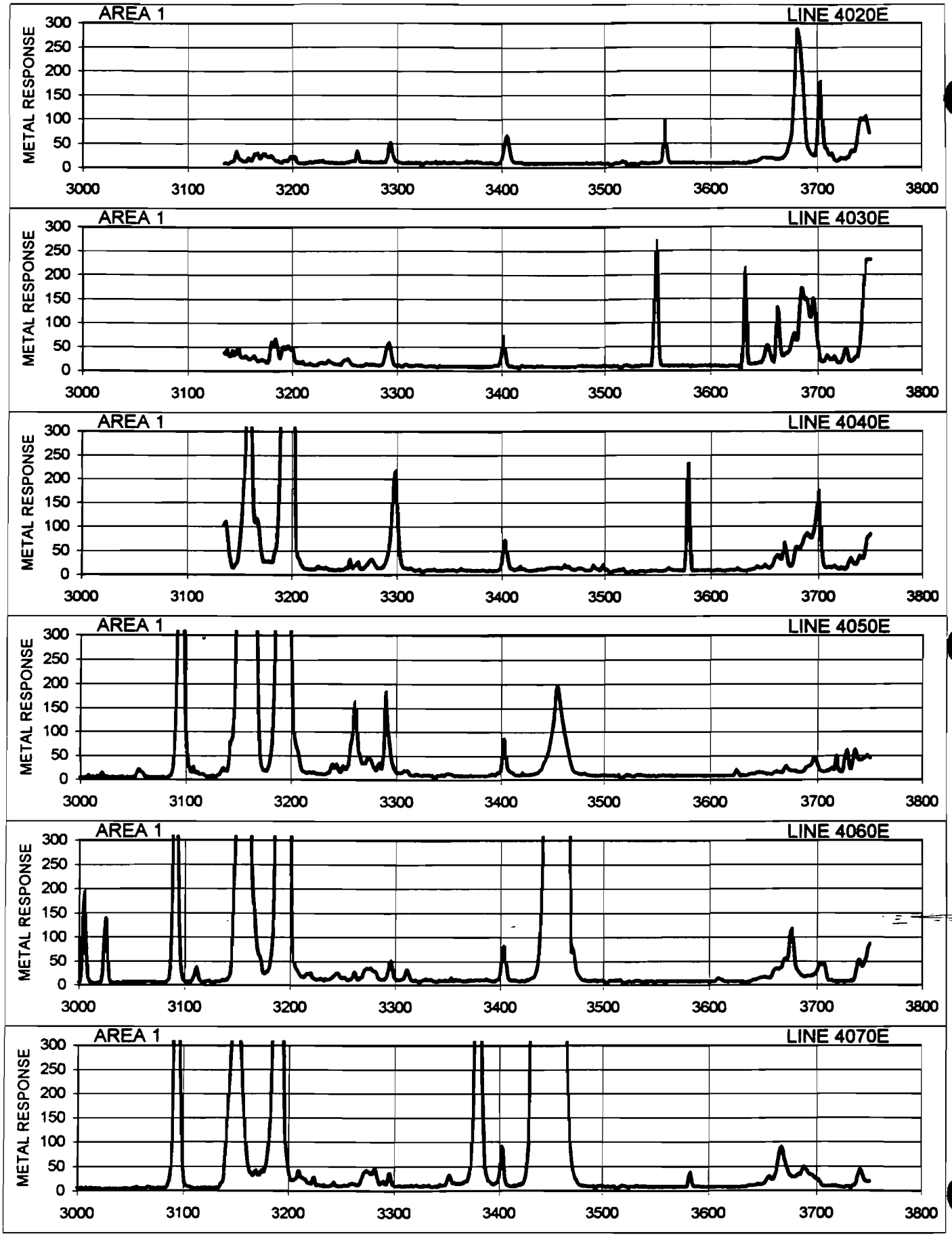
GEOSPHERE MIDWEST

FIGURE D-6



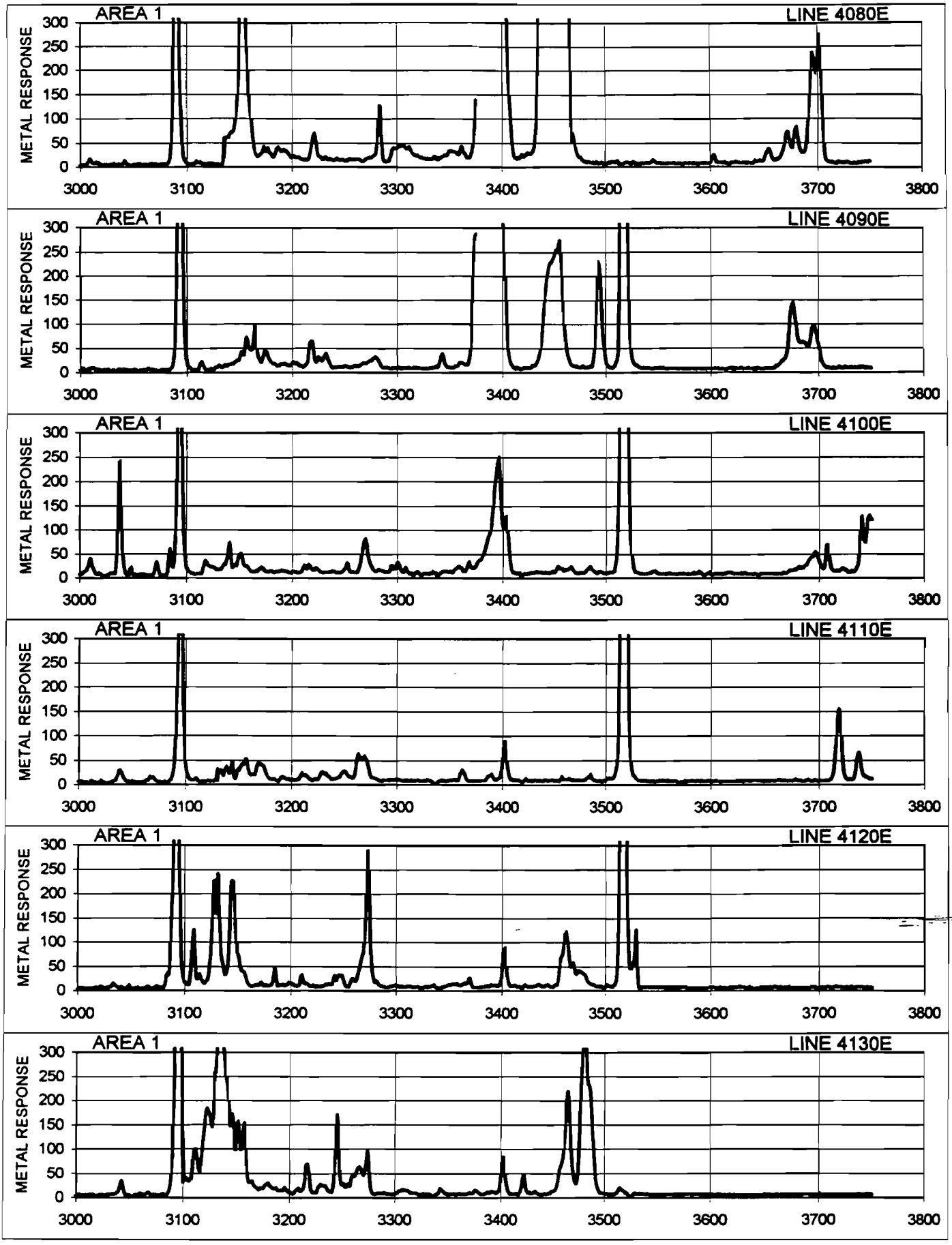
GEOSPHERE MIDWEST

FIGURE D-7



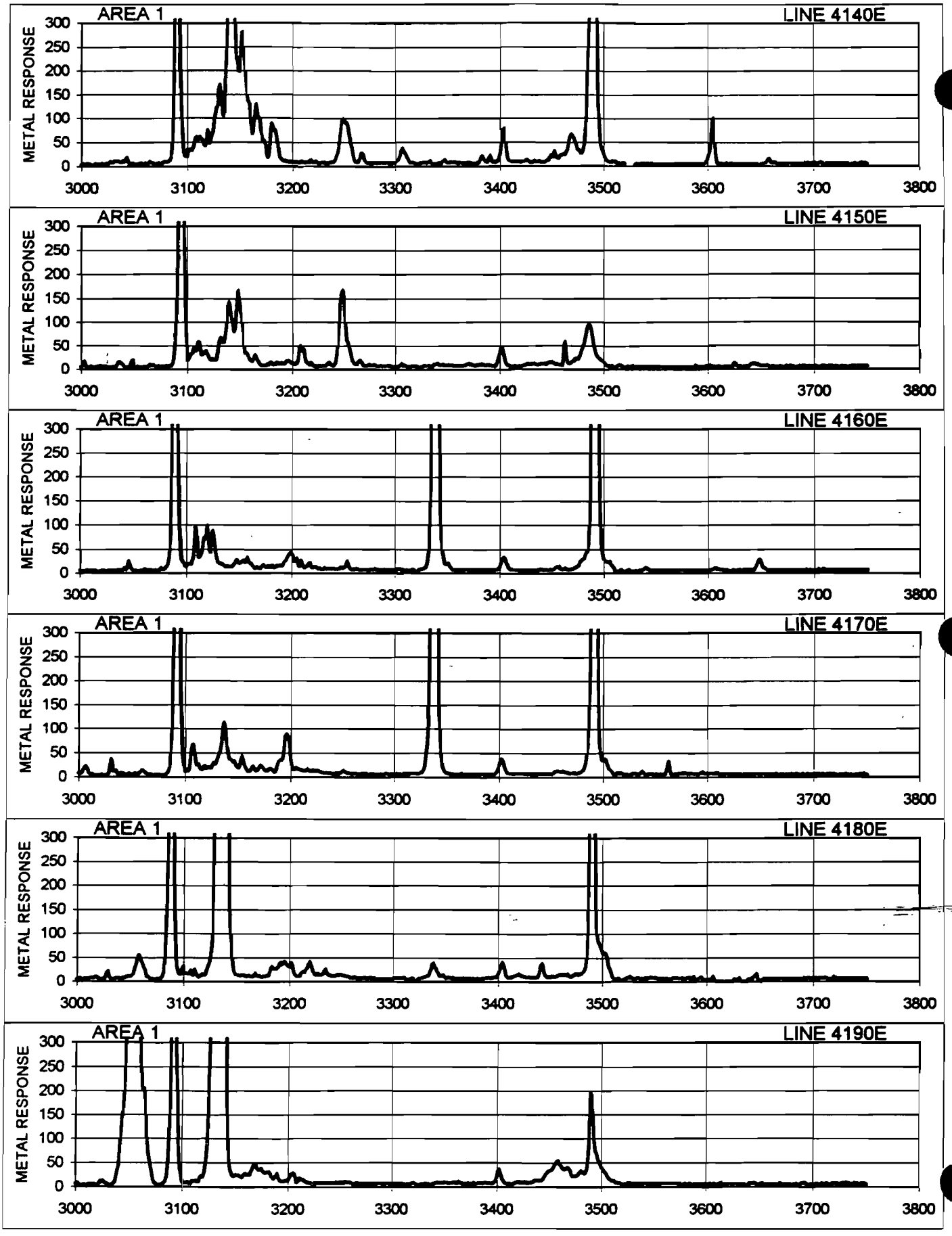
GEOSPHERE MIDWEST

FIGURE D-8



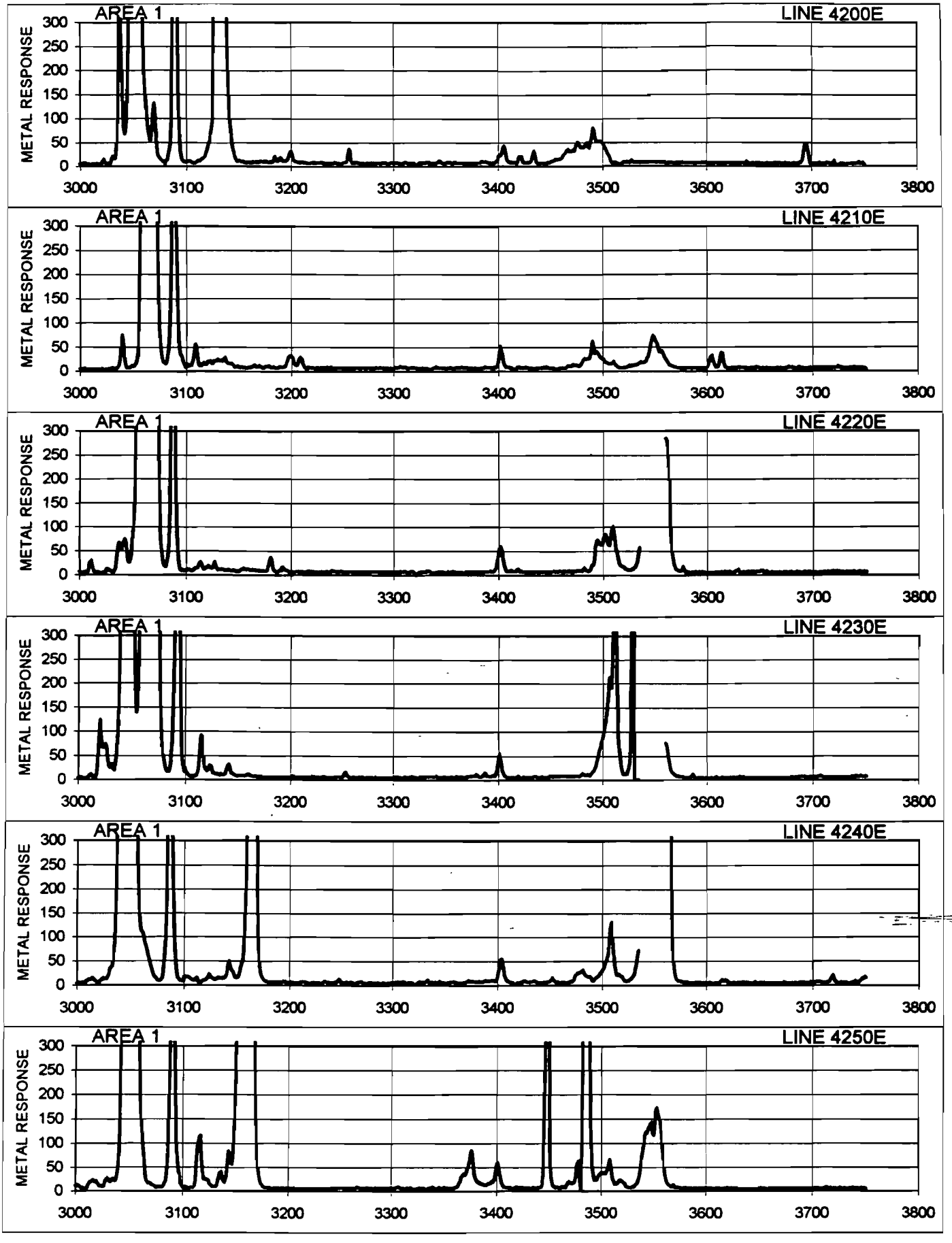
GEOSPHERE MIDWEST

FIGURE D-9



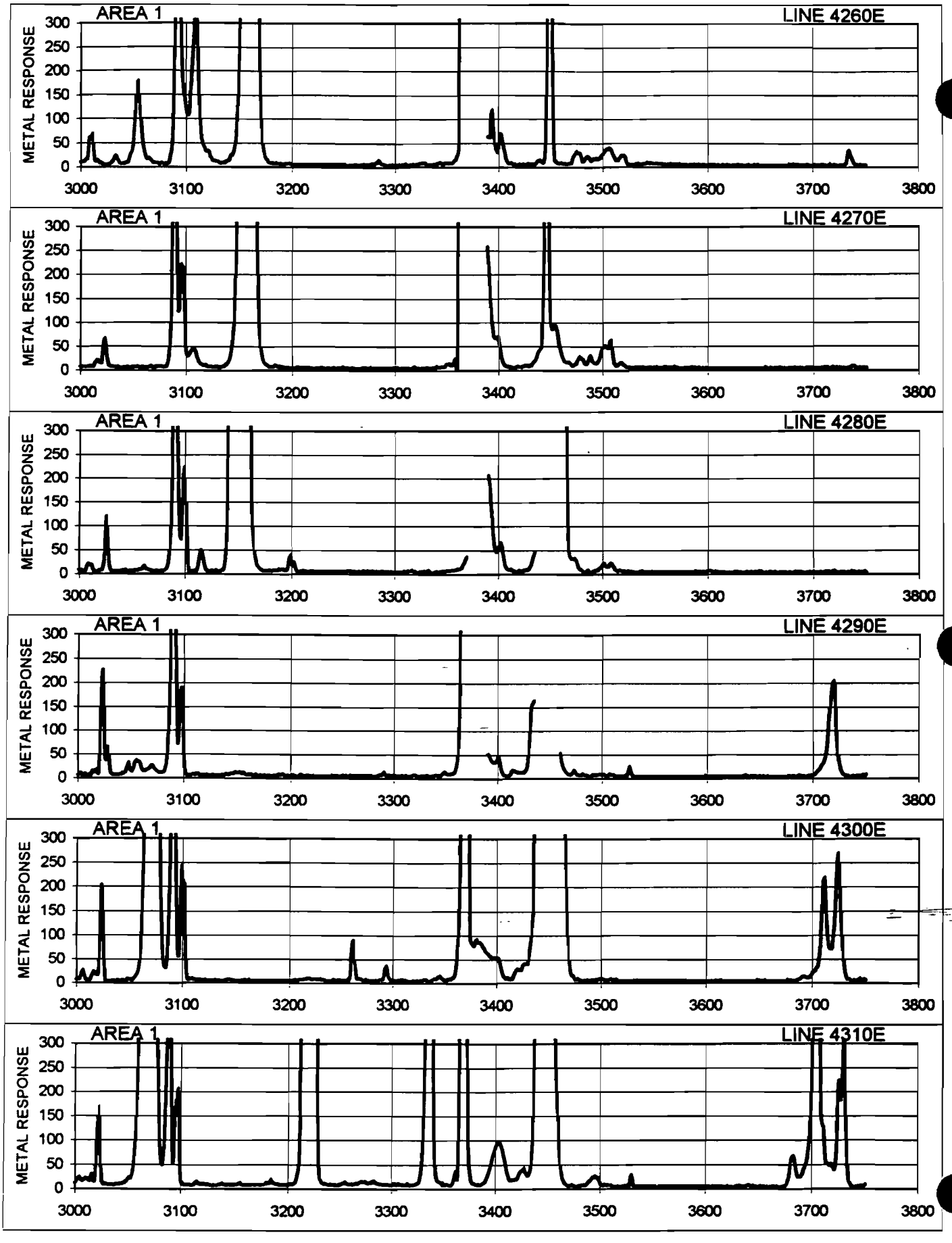
GEOSPHERE MIDWEST

FIGURE D-10



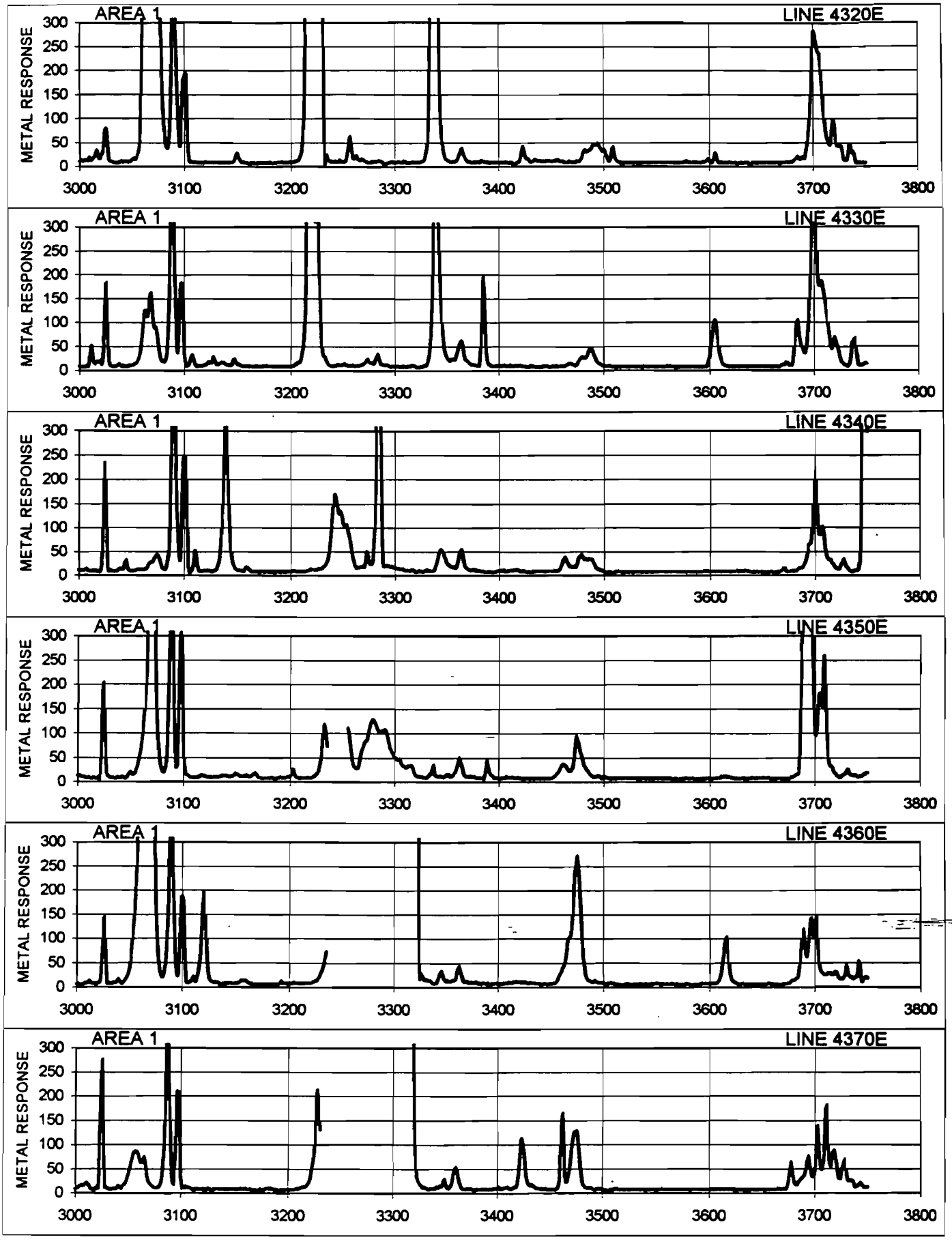
GEOSPHERE MIDWEST

FIGURE D-11



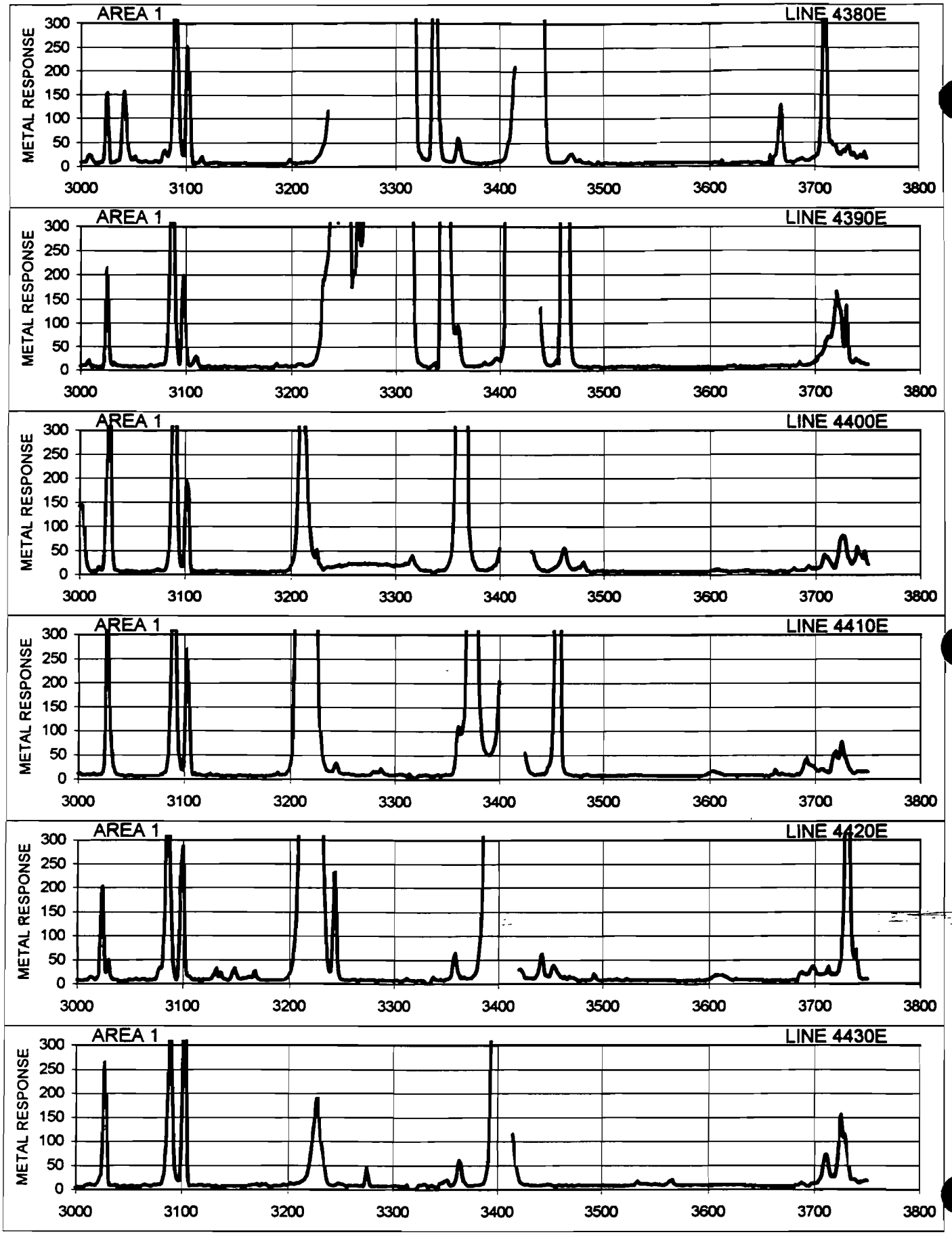
GEOSPHERE MIDWEST

FIGURE D-12



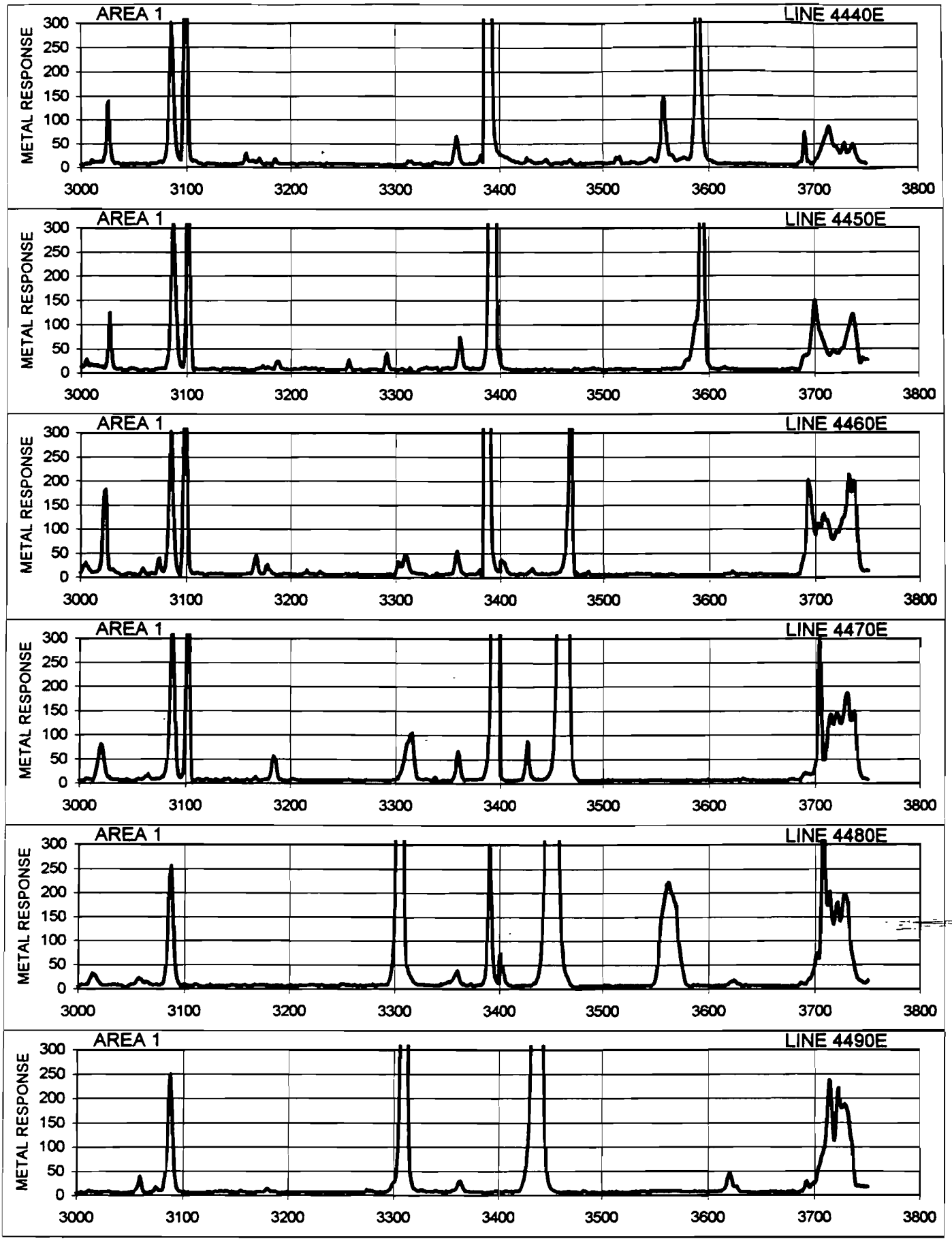
GEOSPHERE MIDWEST

FIGURE D-13



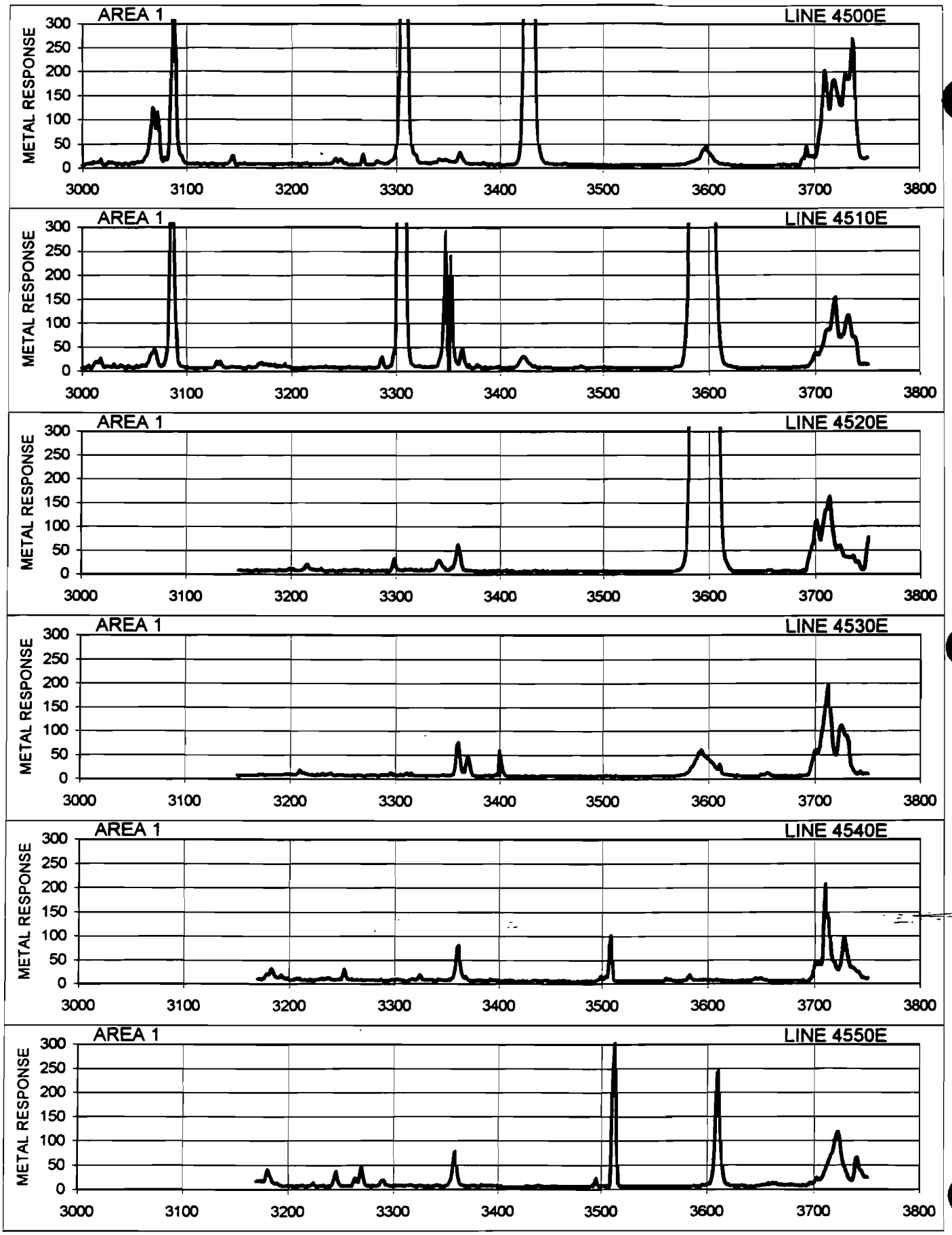
GEOSPHERE MIDWEST

FIGURE D-14



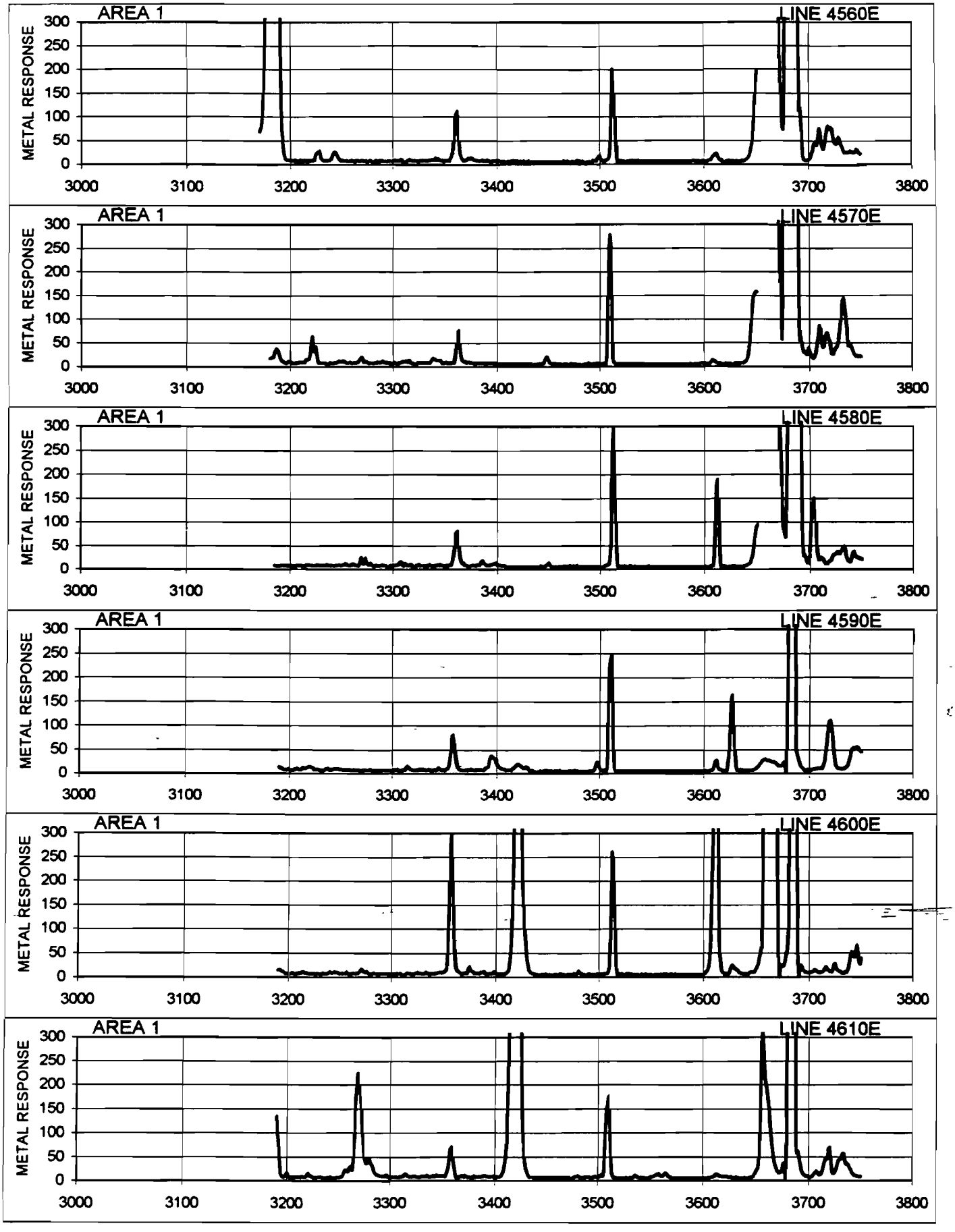
GEOSPHERE MIDWEST

FIGURE D-15



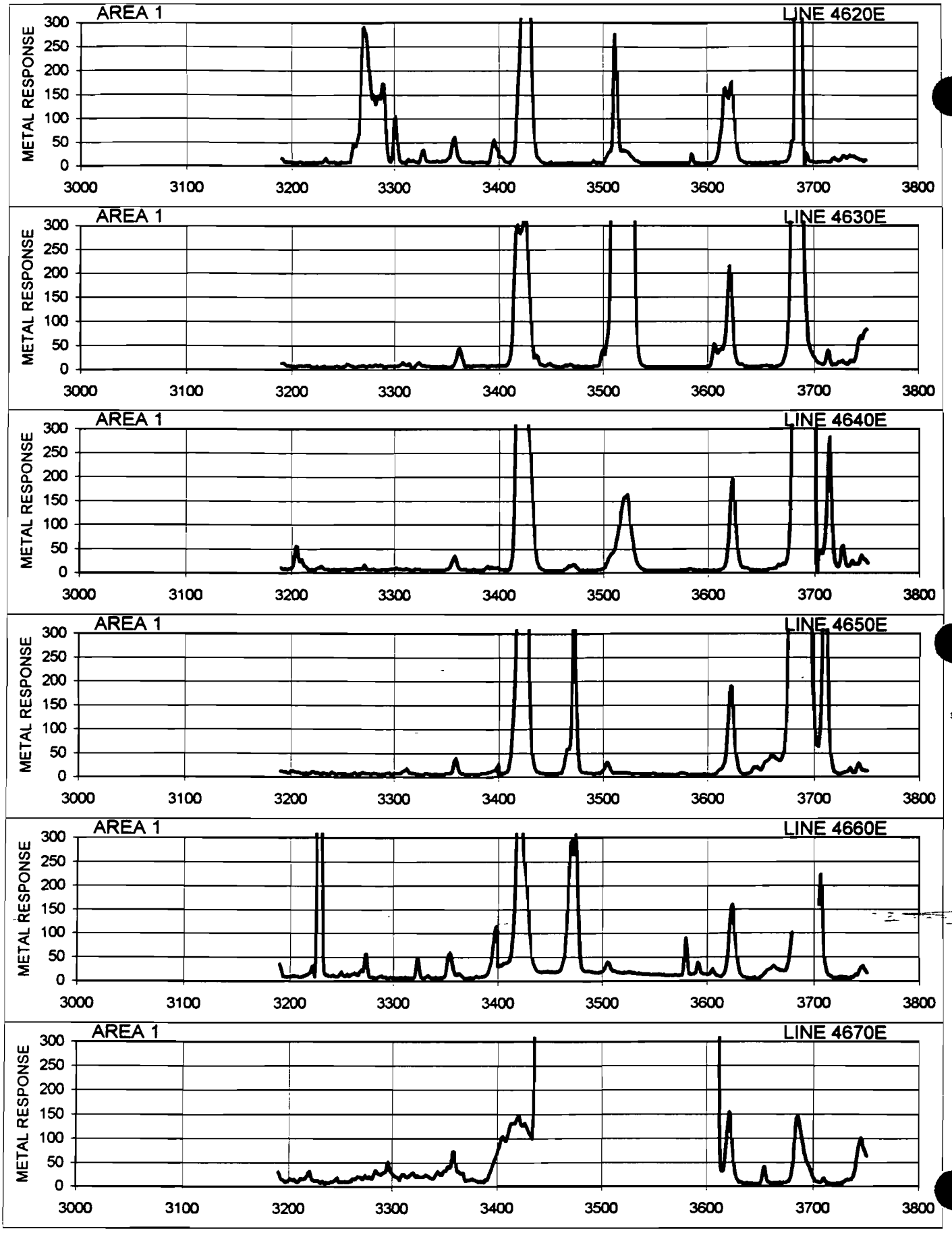
GEOSPHERE MIDWEST

FIGURE D-16



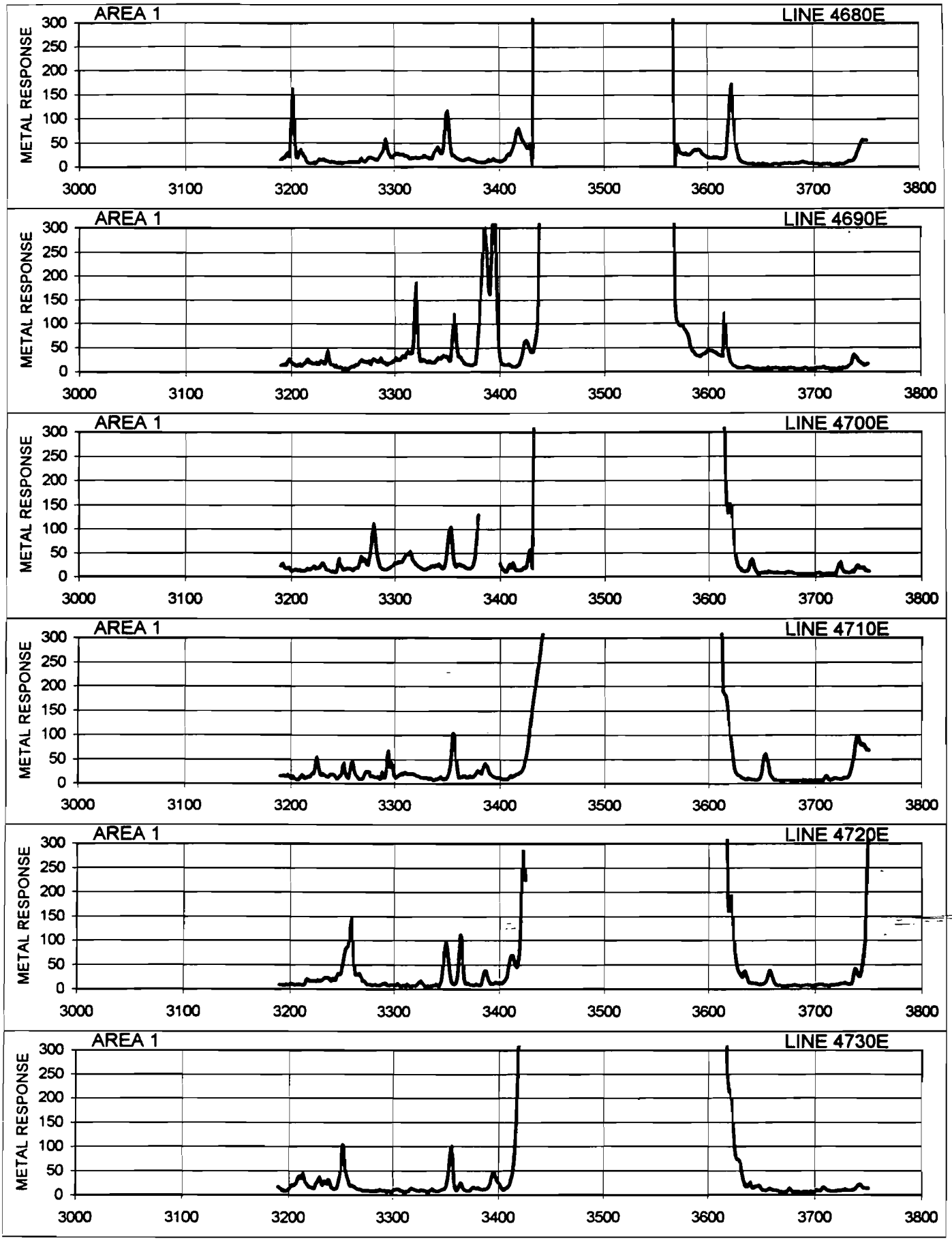
GEOSPHERE MIDWEST

FIGURE D-17



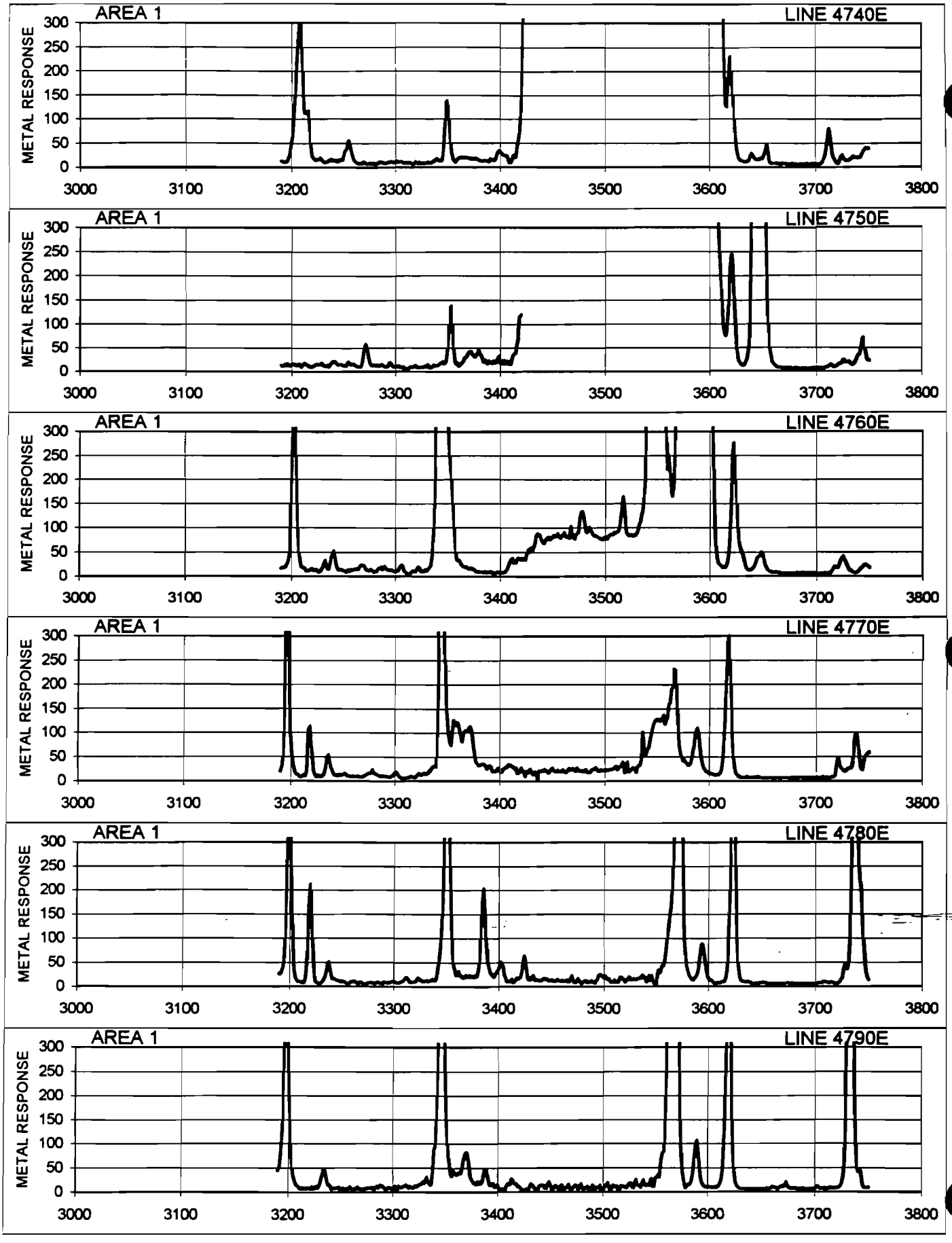
GEOSPHERE MIDWEST

FIGURE D-18



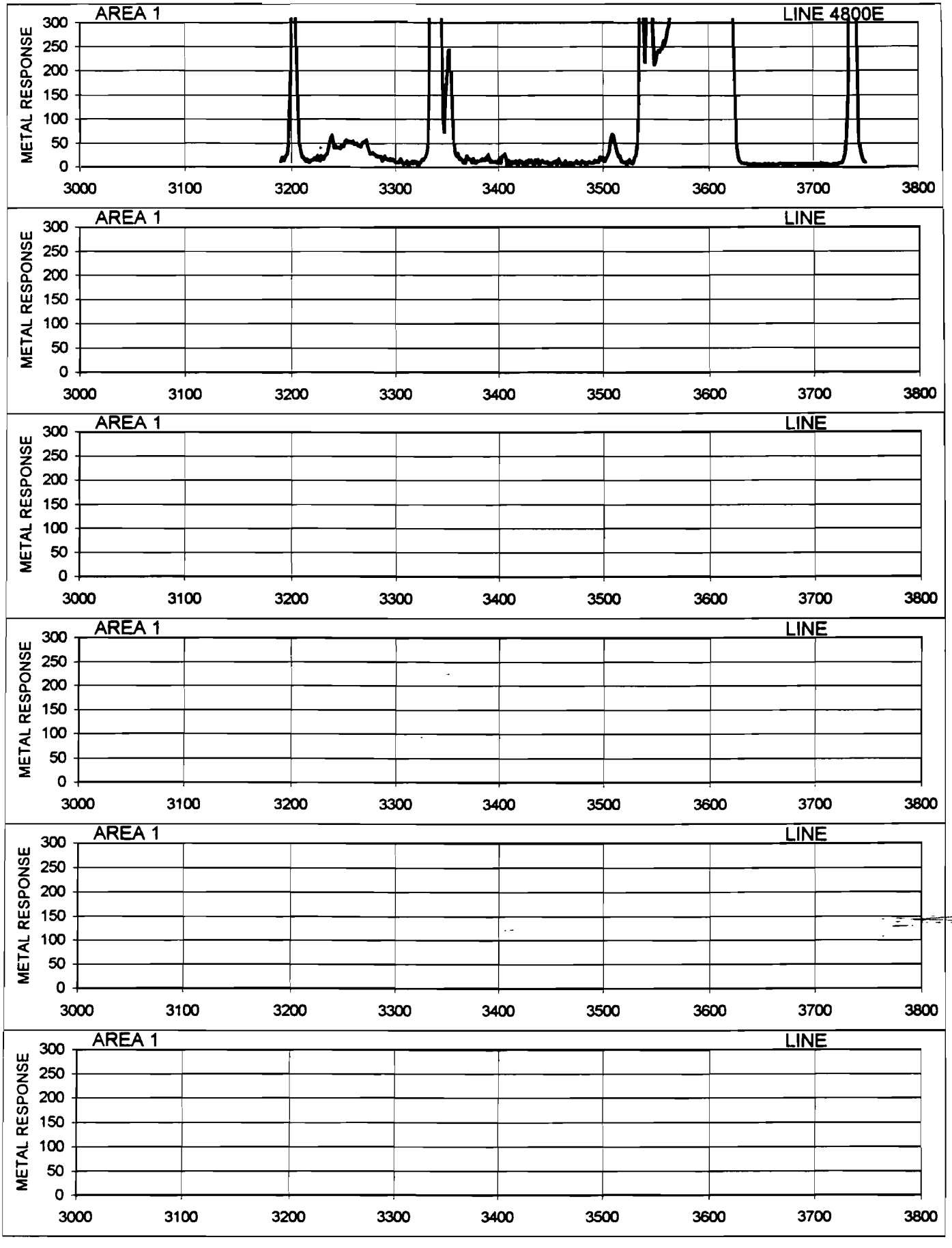
GEOSPHERE MIDWEST

FIGURE D-19



GEOSPHERE MIDWEST

FIGURE D-20



GEOSPHERE MIDWEST

FIGURE D-21

APPENDIX E

SITE 4: EM31 PROFILE DATA

This appendix is a compilation of all EM31 profile data obtained at Site 4. Locations of these EM lines are given in Figure 4.2. The following profiles include line number (easting coordinate), conductivity and inphase (vertical) scales and station location labels (northing coordinates). Conductivity values are given in millimhos/meter (mmhos/m), inphase values are given in parts per thousand (ppt) and location coordinates are in feet.

E1. EM31 SURVEY: N-S PROFILES FROM SITE 4

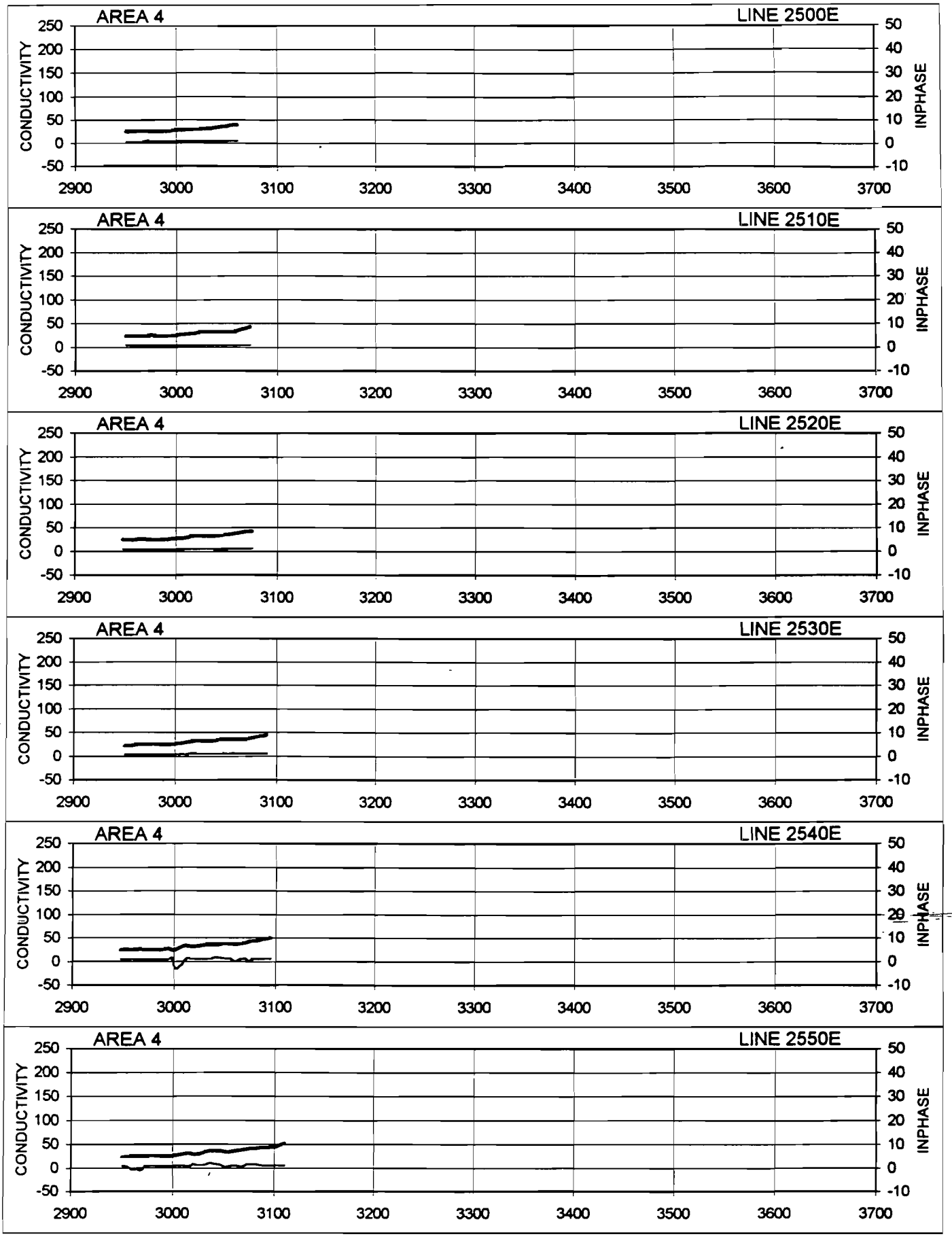
Figures E-1 to E-14.

E2. EM31 SURVEY: SW-NE PROFILES FROM SITE 4

Figure E-15.

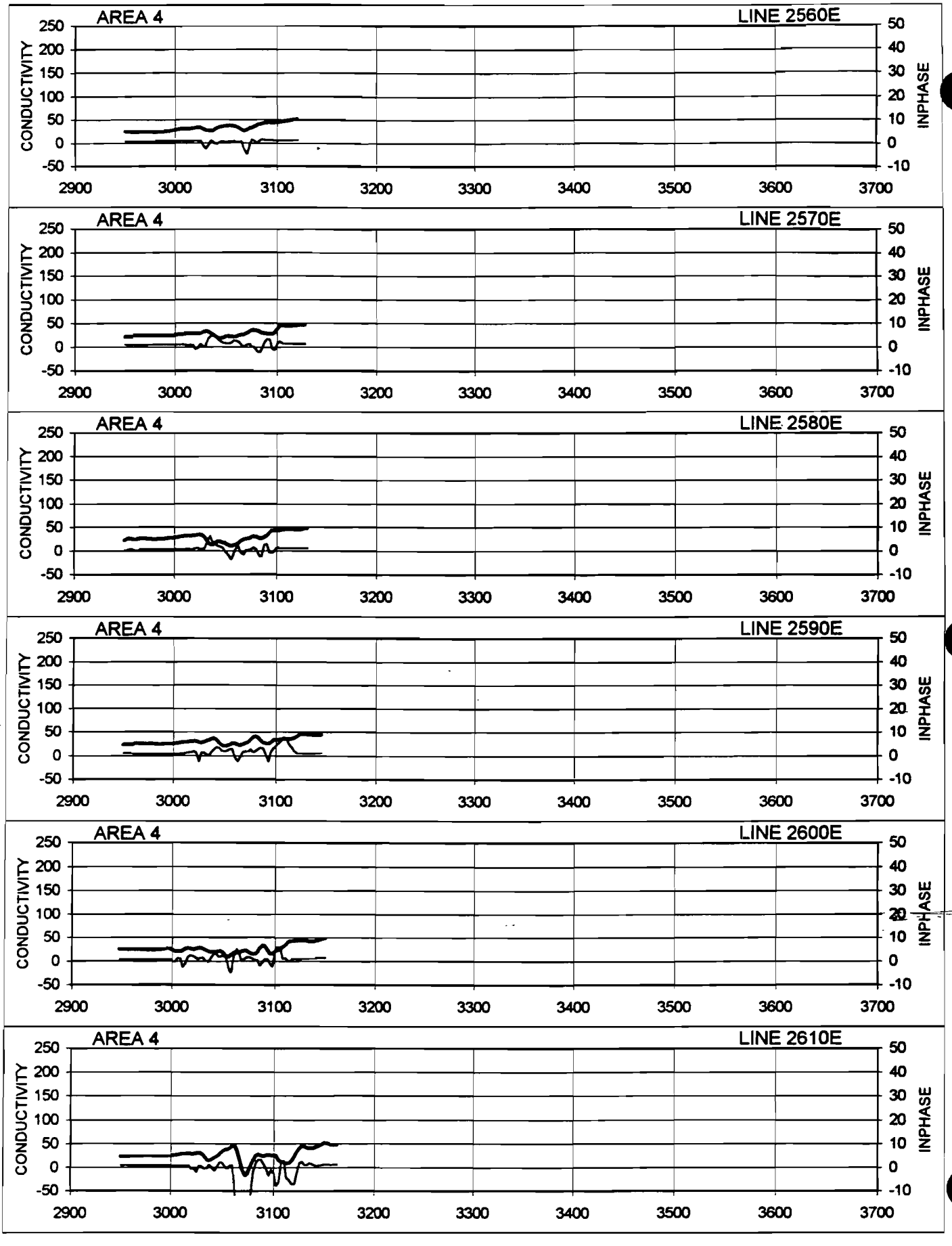
E3. EM31 SURVEY: SE-NW PROFILES FROM SITE 4

Figure E-16.



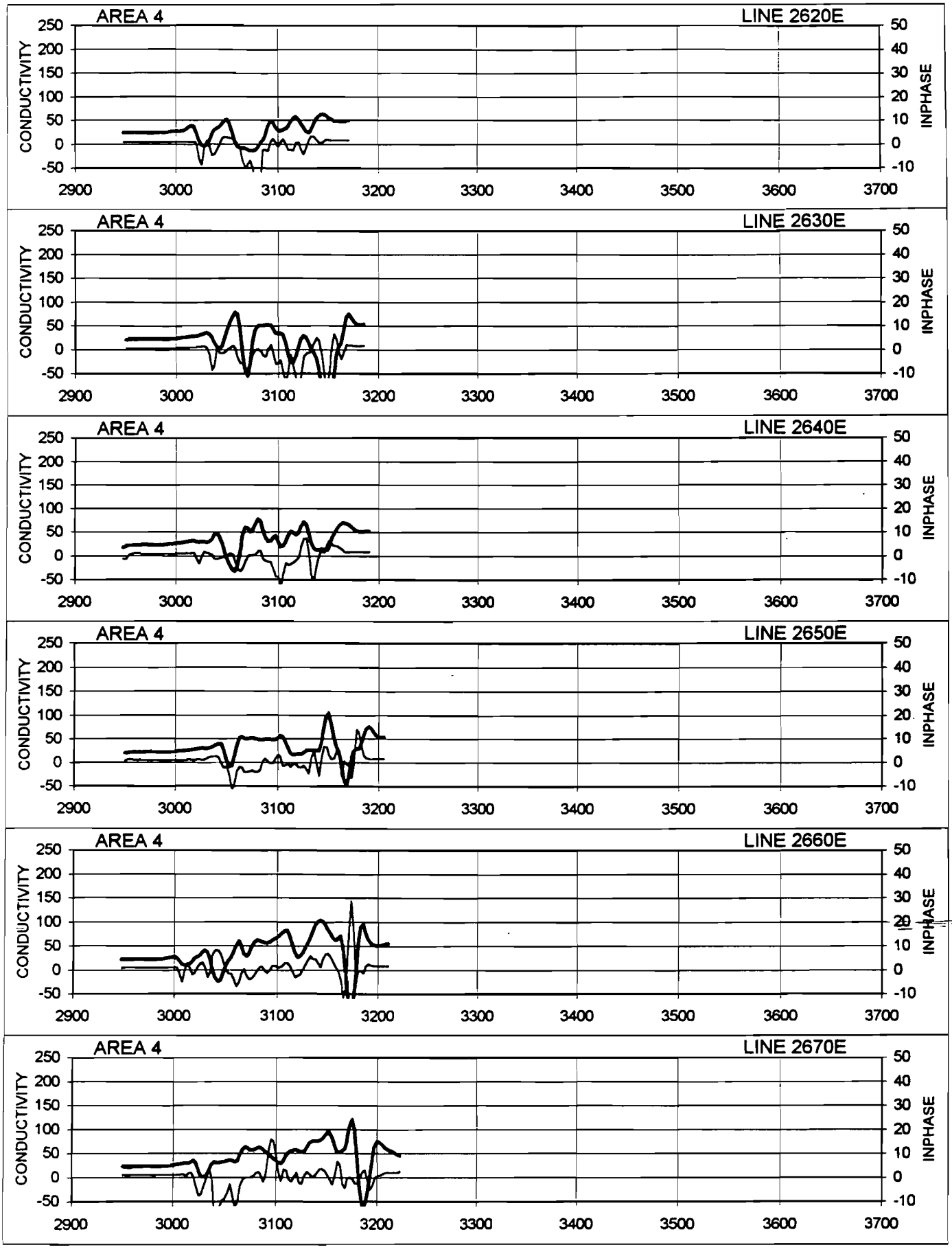
GEOSPHERE MIDWEST

FIGURE E-1



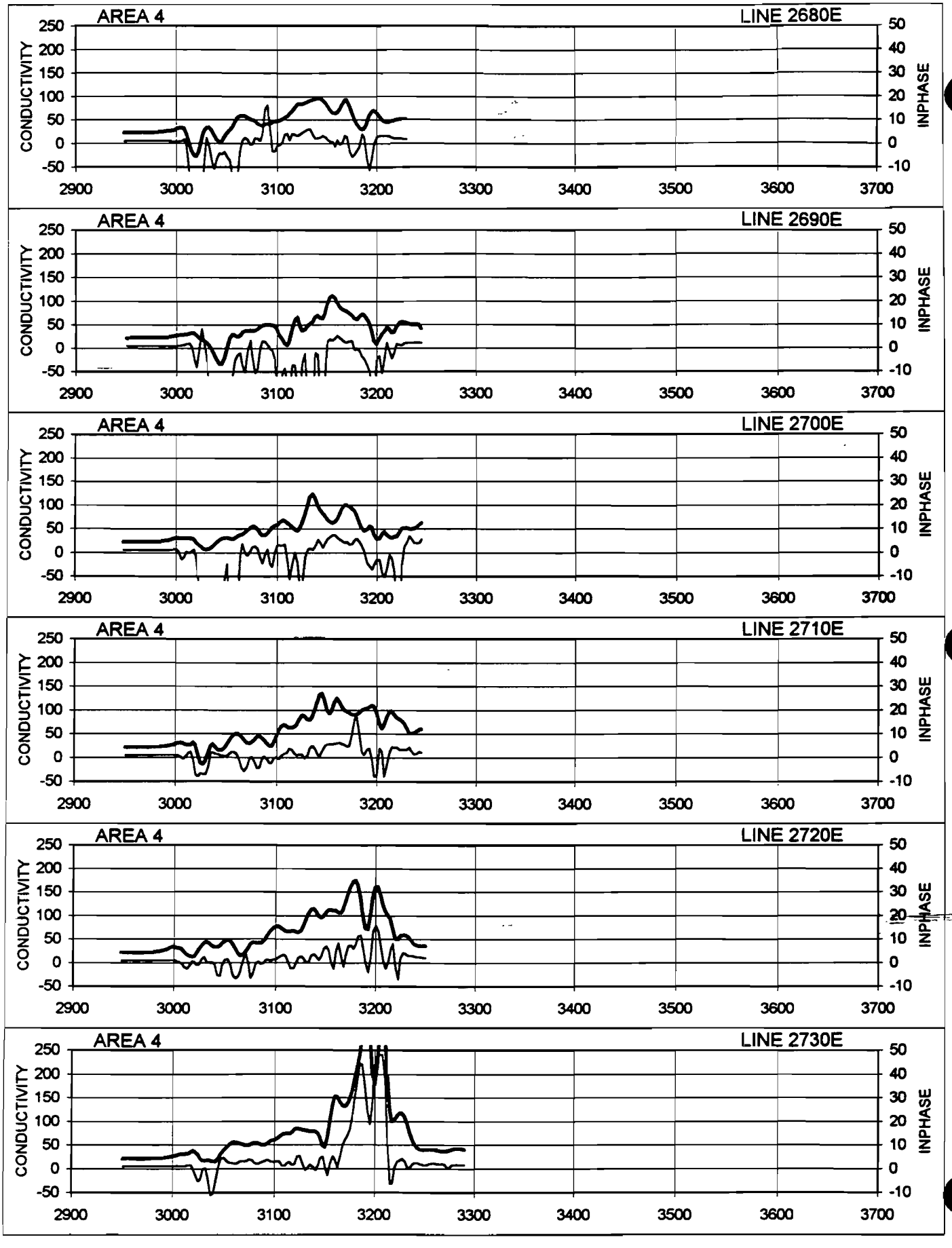
GEOSPHERE MIDWEST

FIGURE E-2



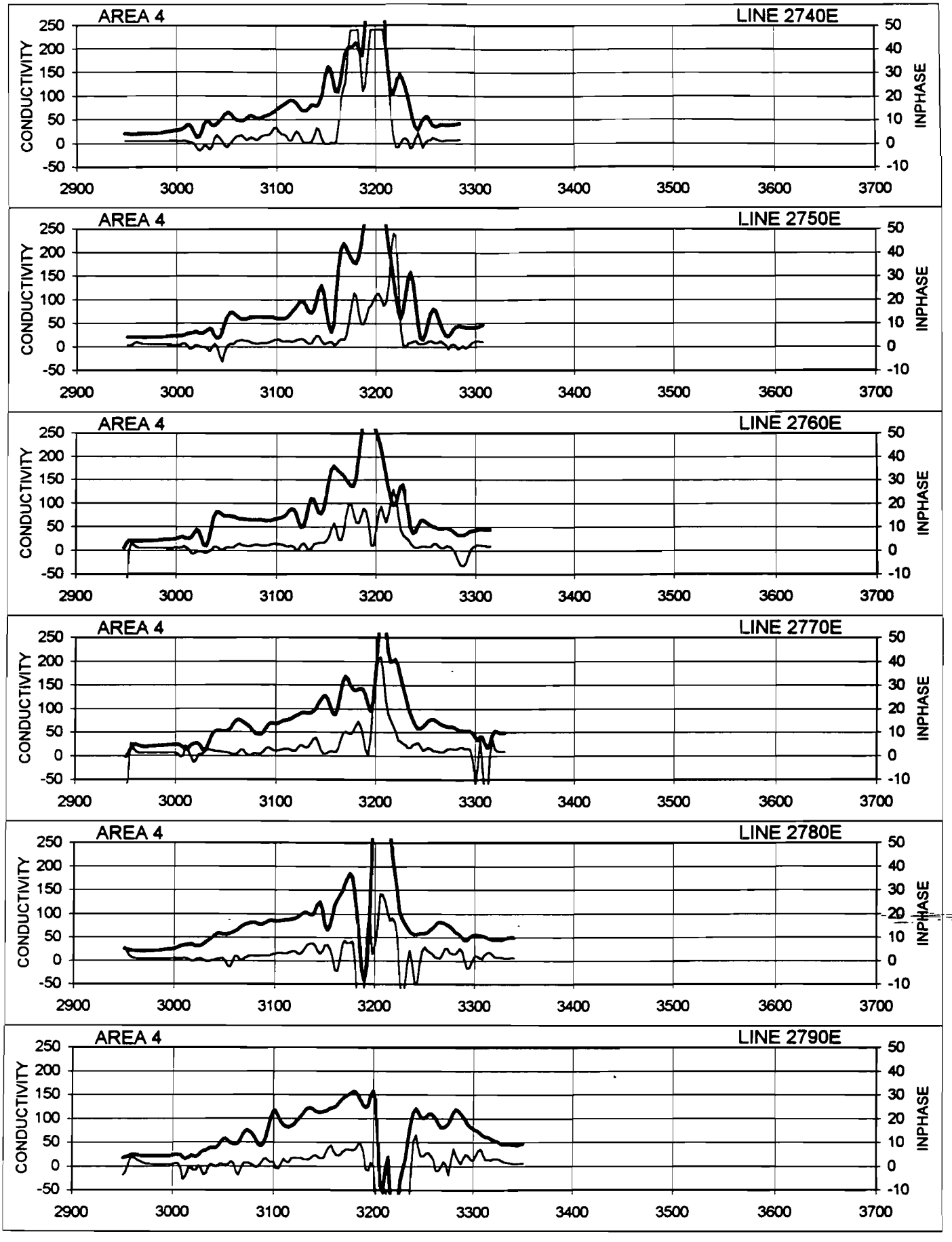
GEOSPHERE MIDWEST

FIGURE E-3



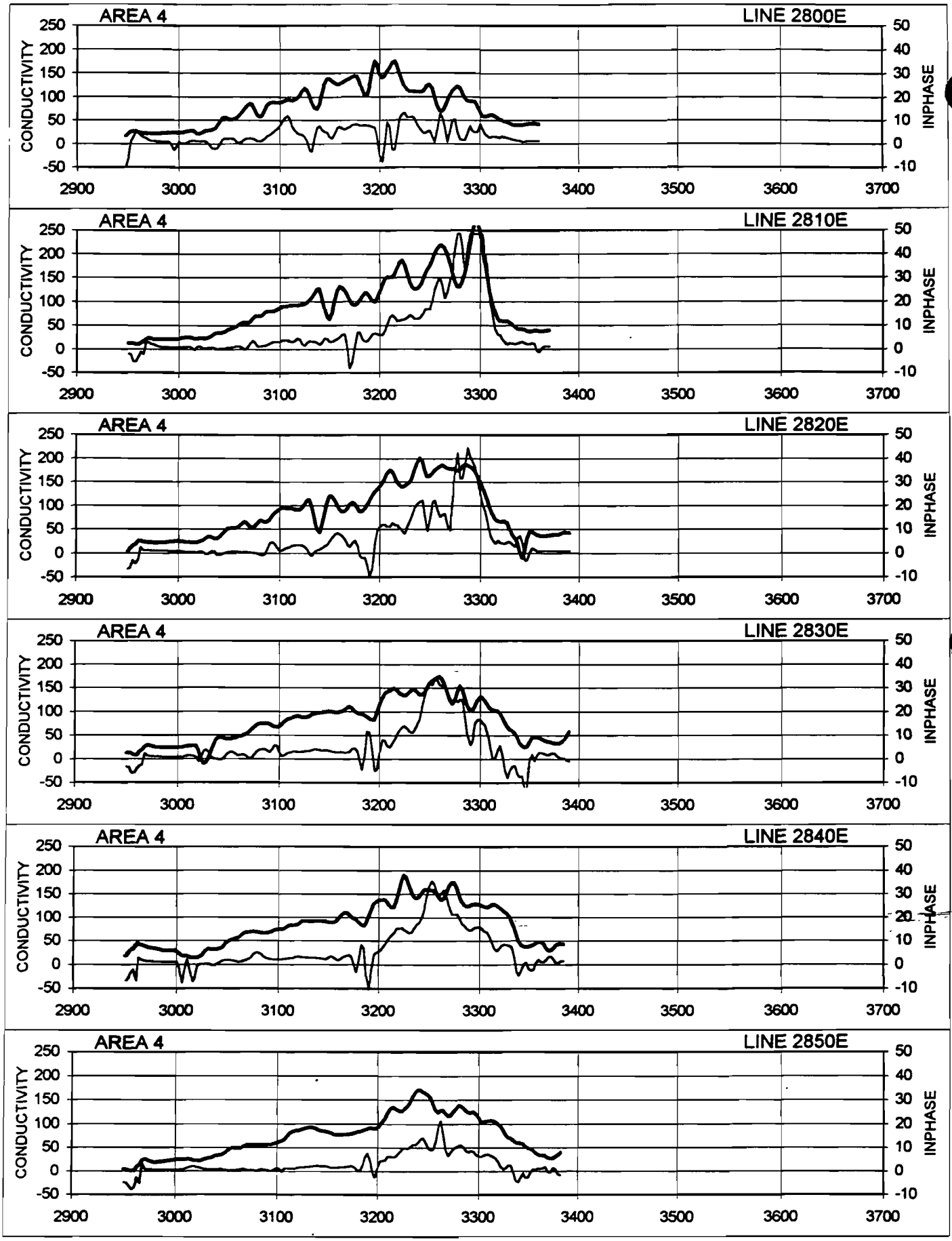
GEOSPHERE MIDWEST

FIGURE E-4



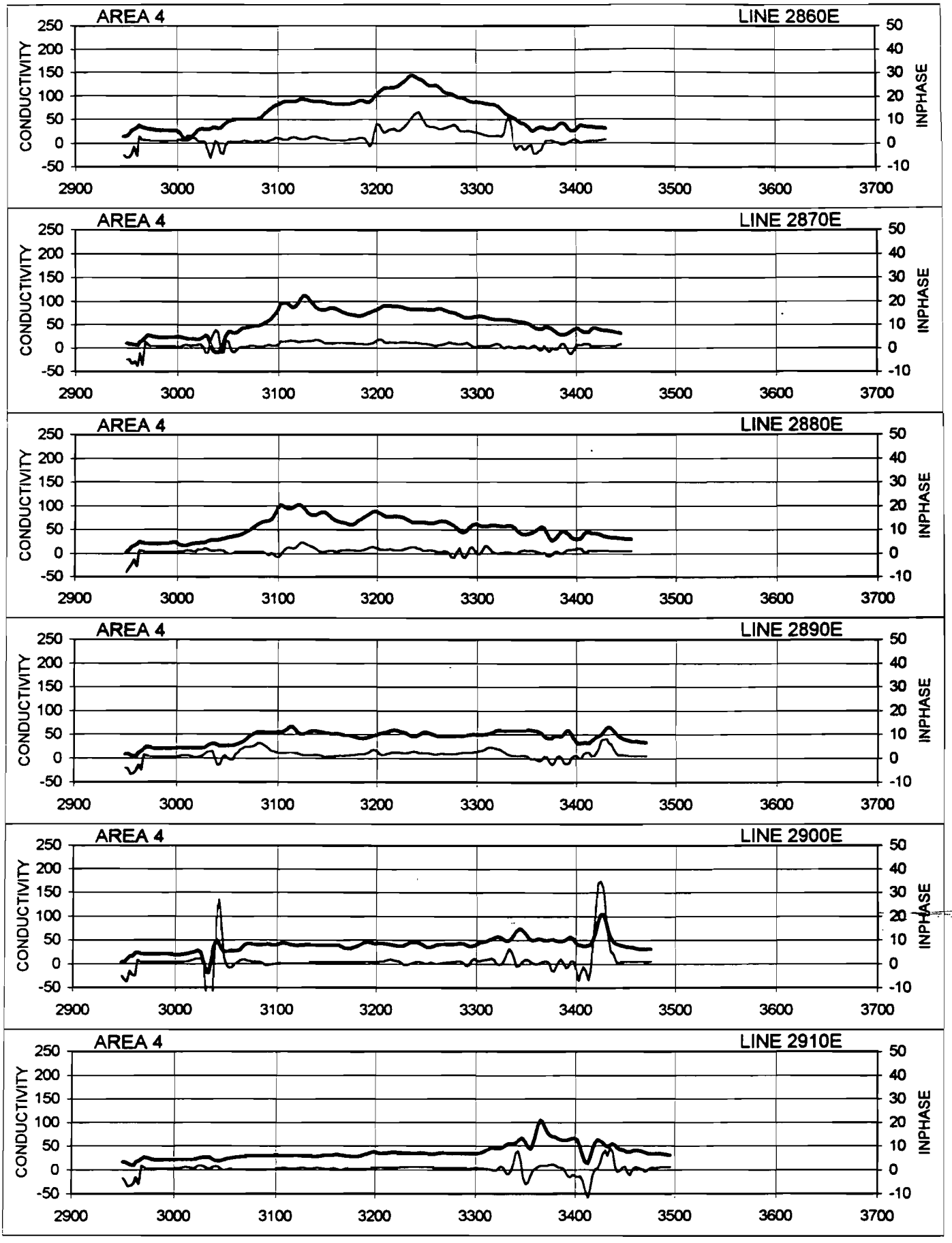
GEOSPHERE MIDWEST

FIGURE E-5



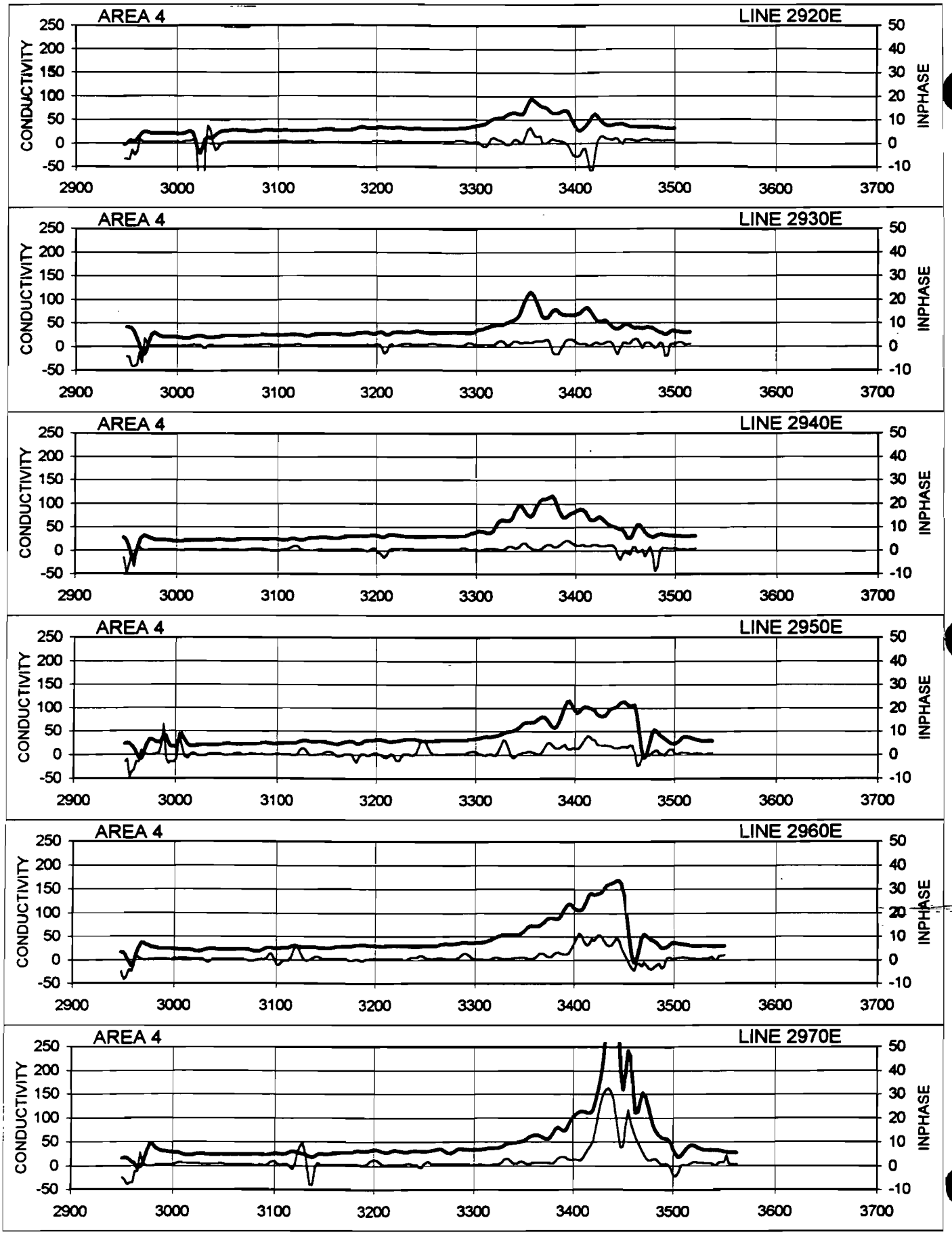
GEOSPHERE MIDWEST

FIGURE E-6



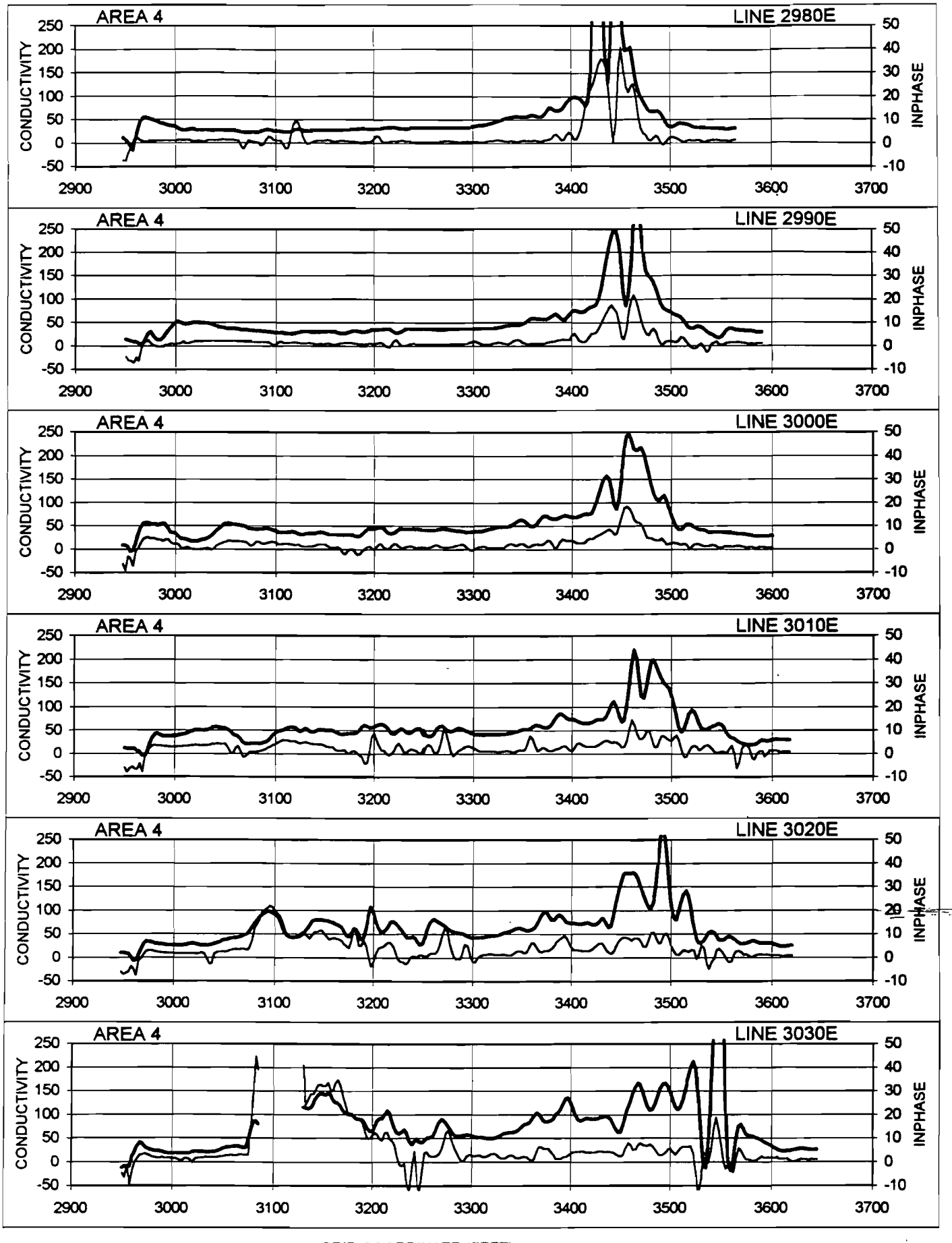
GEOSPHERE MIDWEST

FIGURE E-7



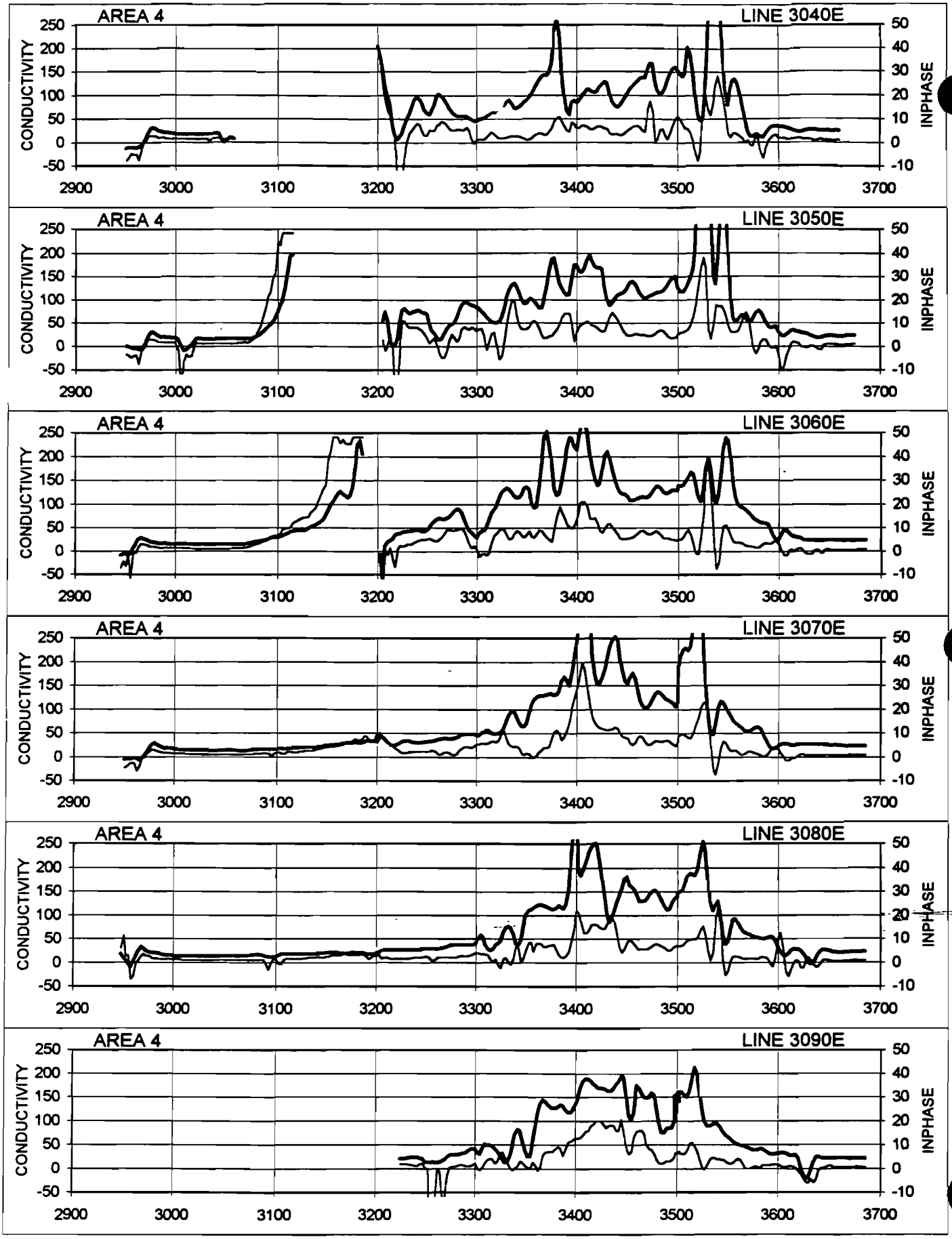
GEOSPHERE MIDWEST

FIGURE E-8



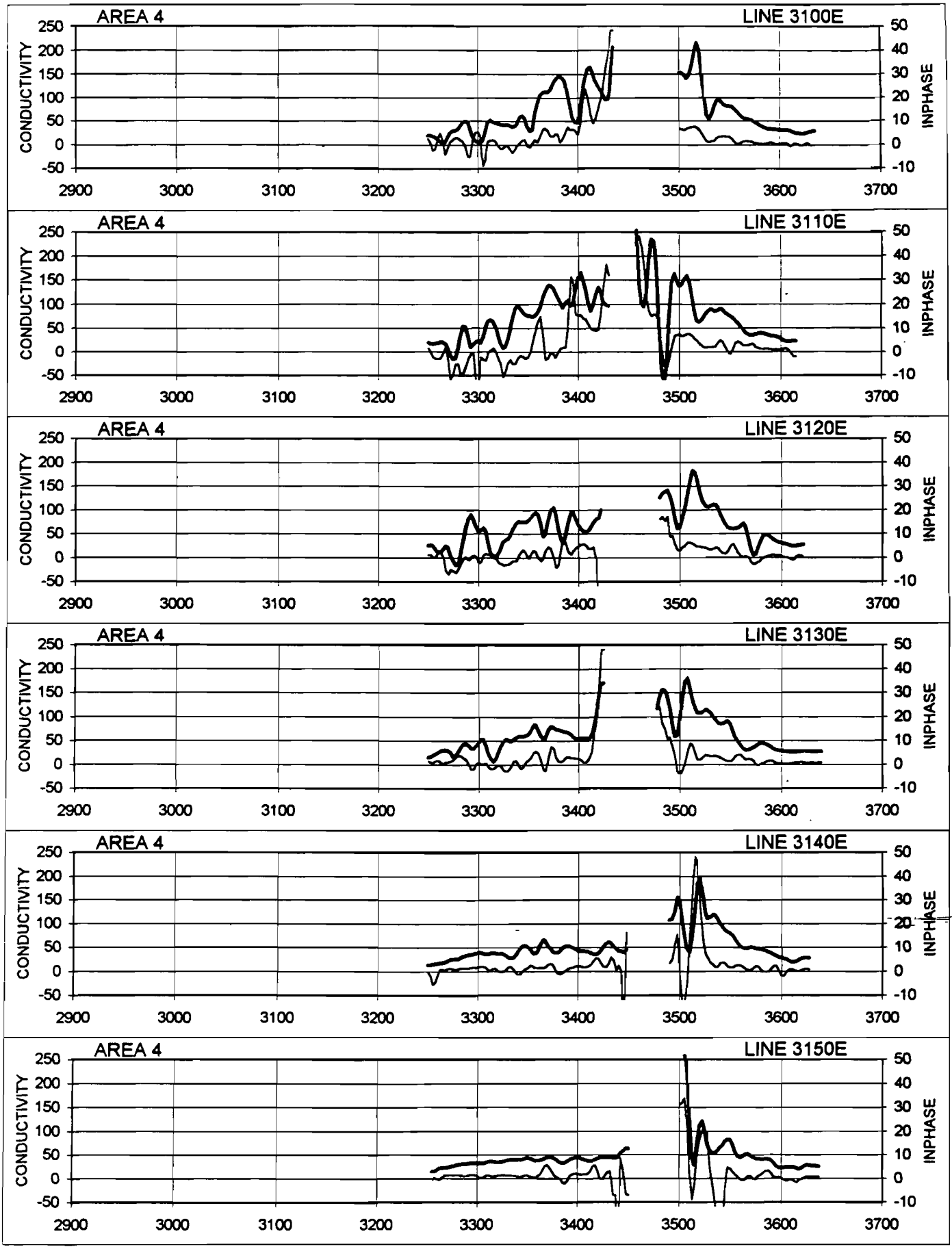
GEOSPHERE MIDWEST

FIGURE E-9



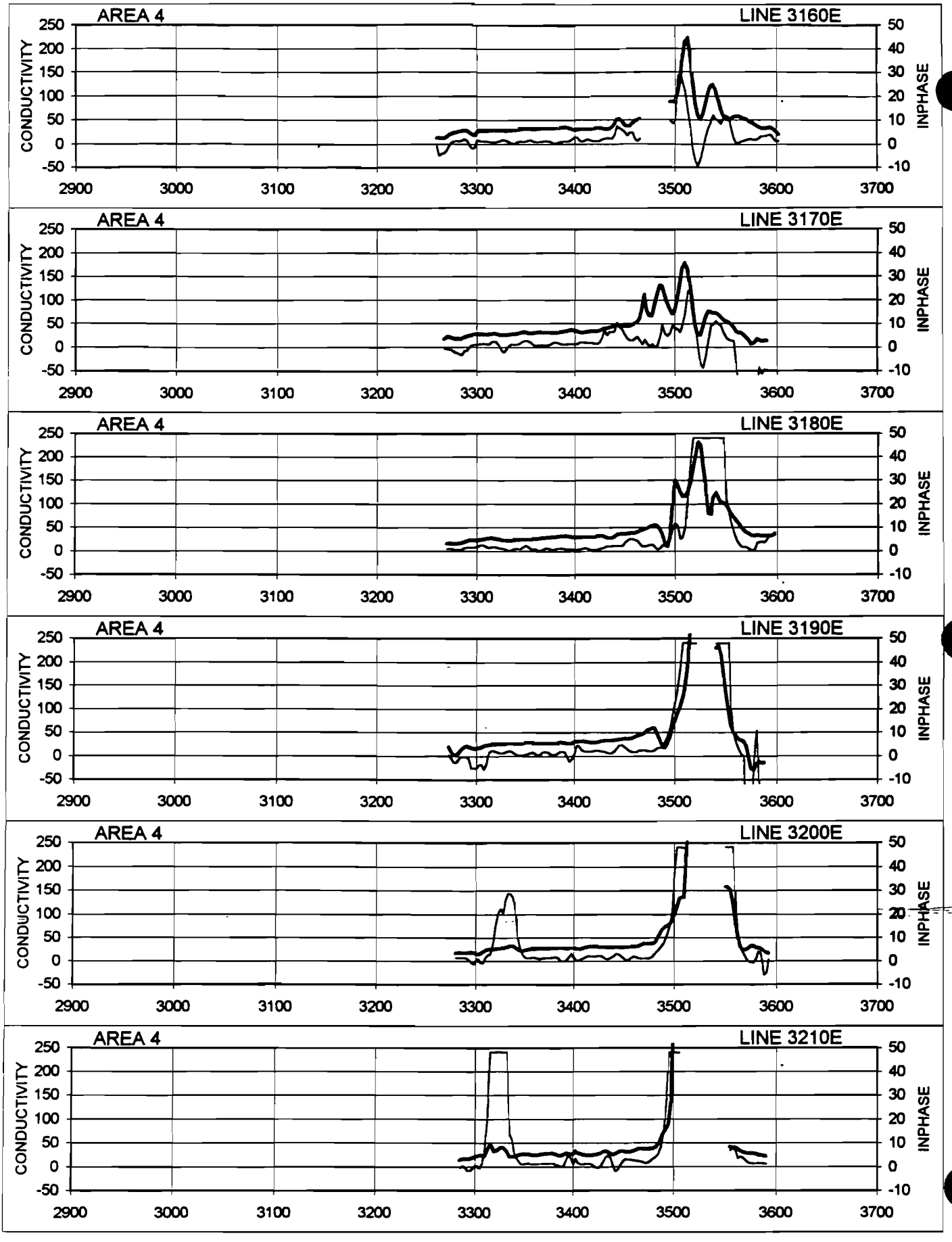
GEOSPHERE MIDWEST

FIGURE E-10



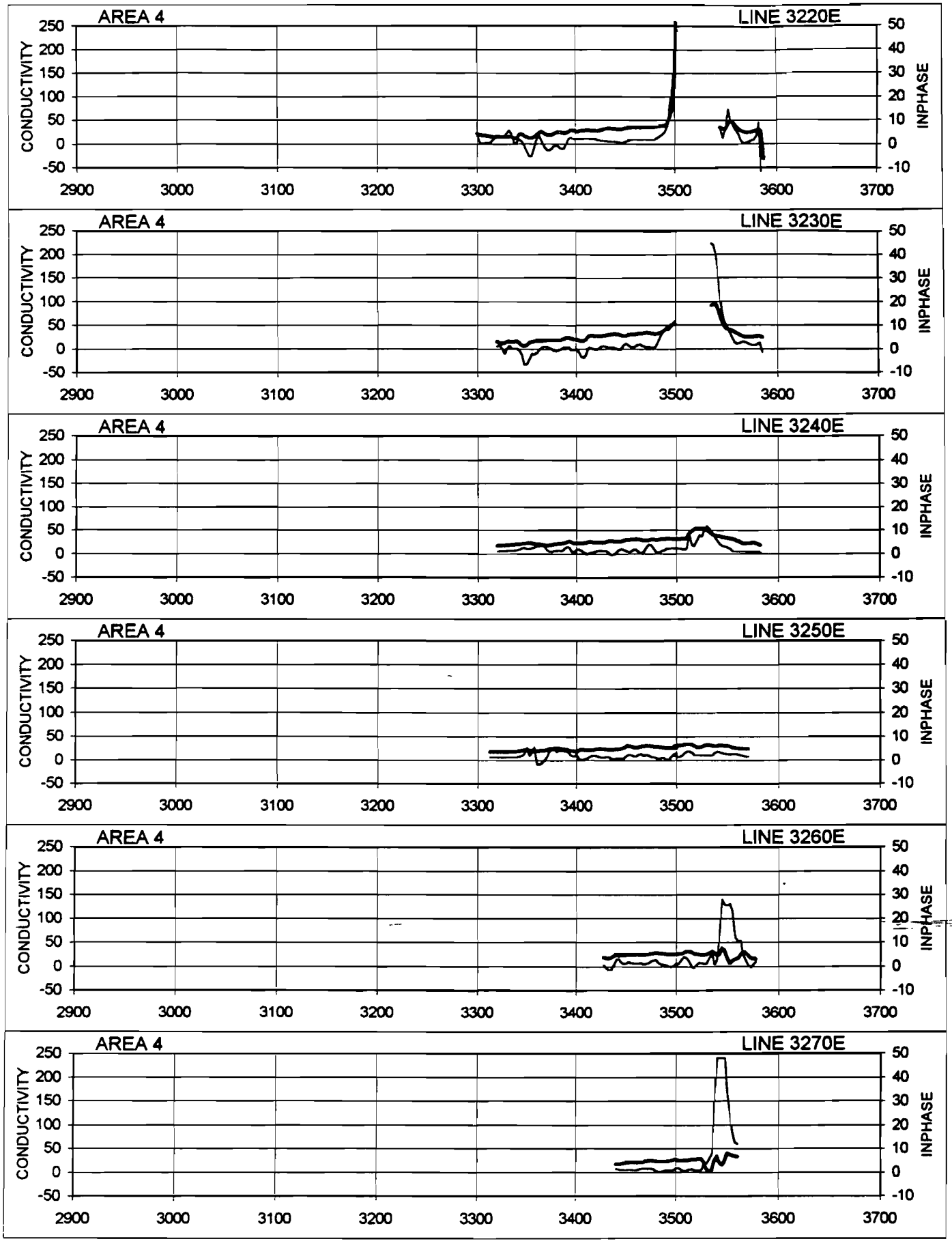
GEOSPHERE MIDWEST

FIGURE E-11



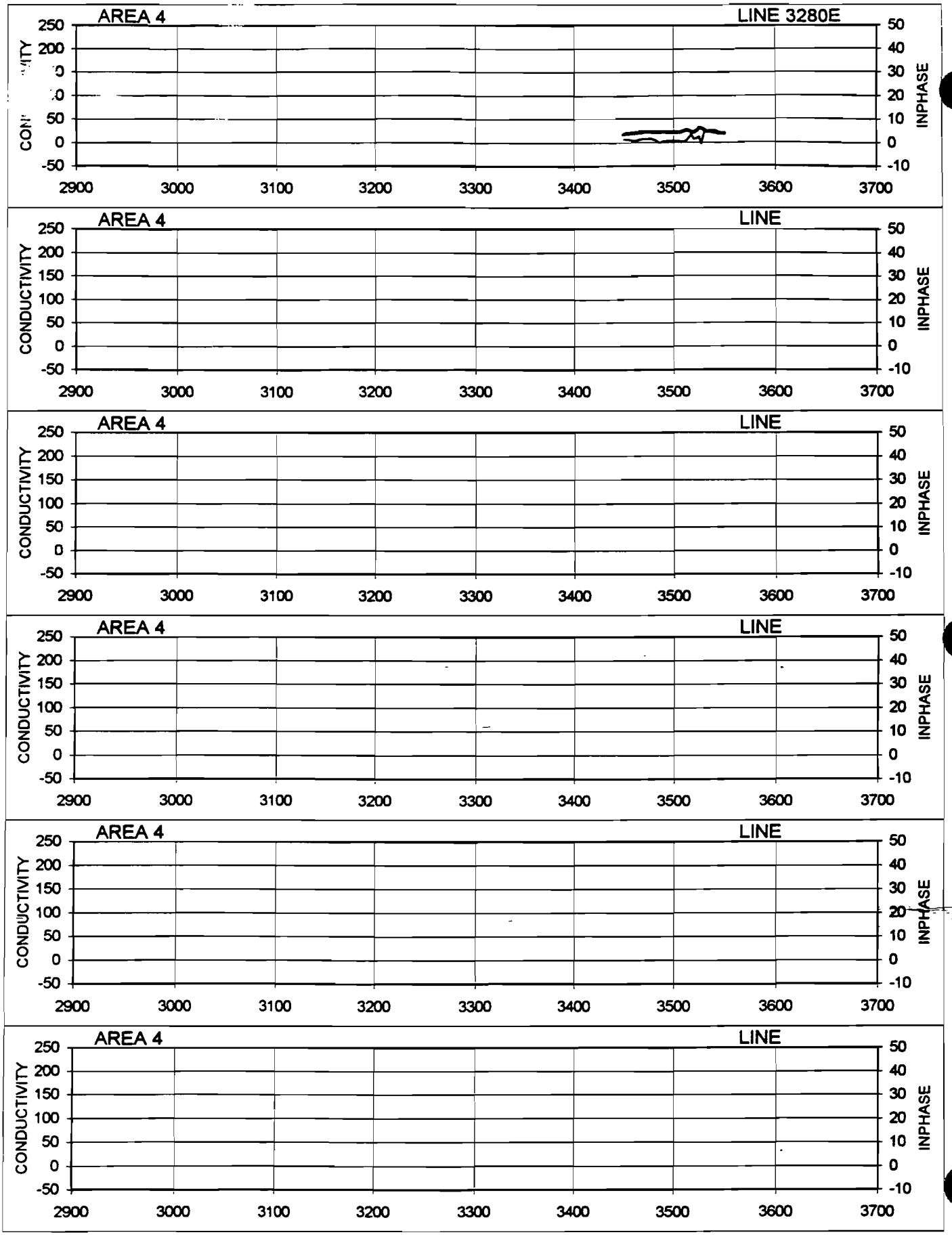
GEOSPHERE MIDWEST

FIGURE E-12



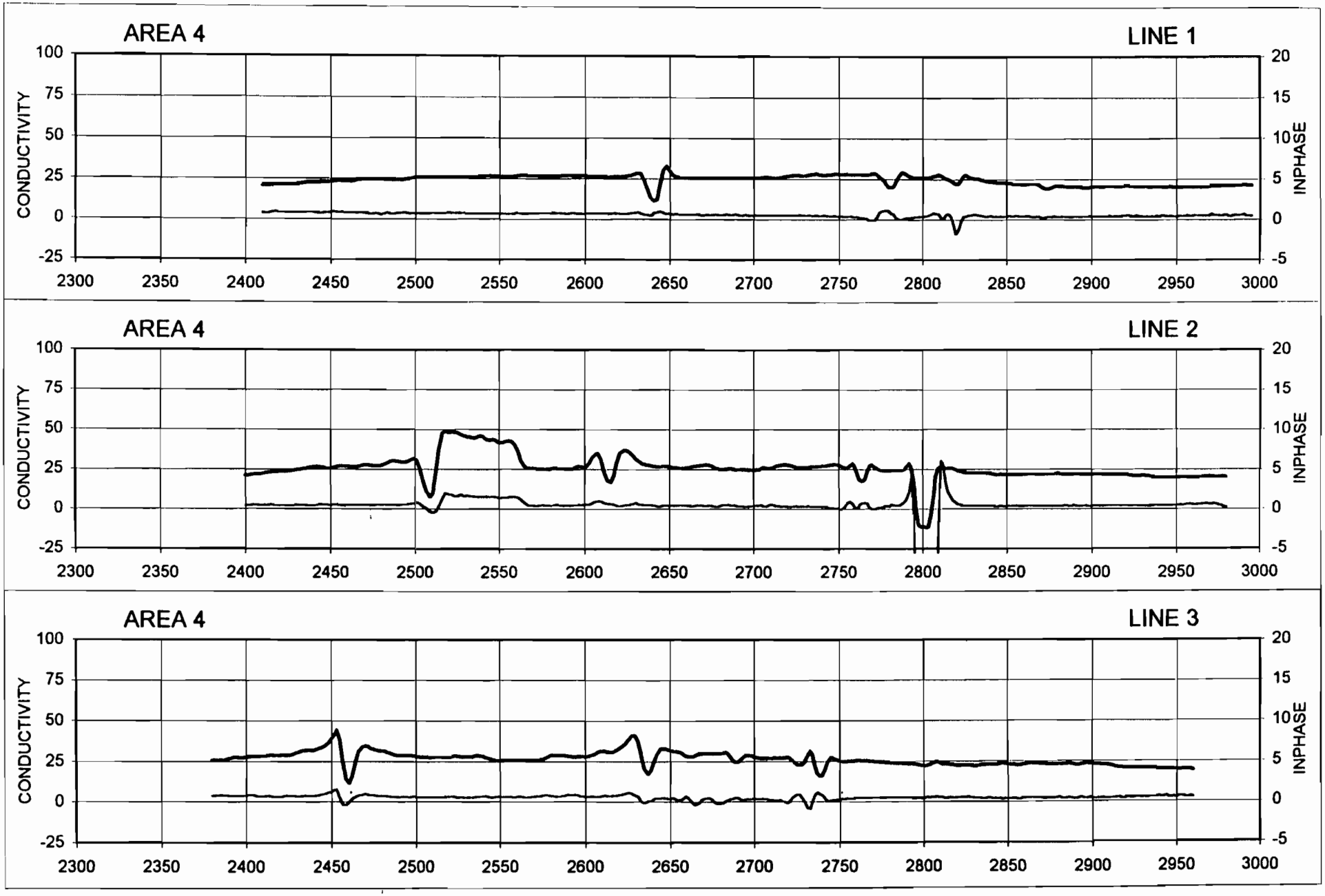
GEOSPHERE MIDWEST

FIGURE E-13



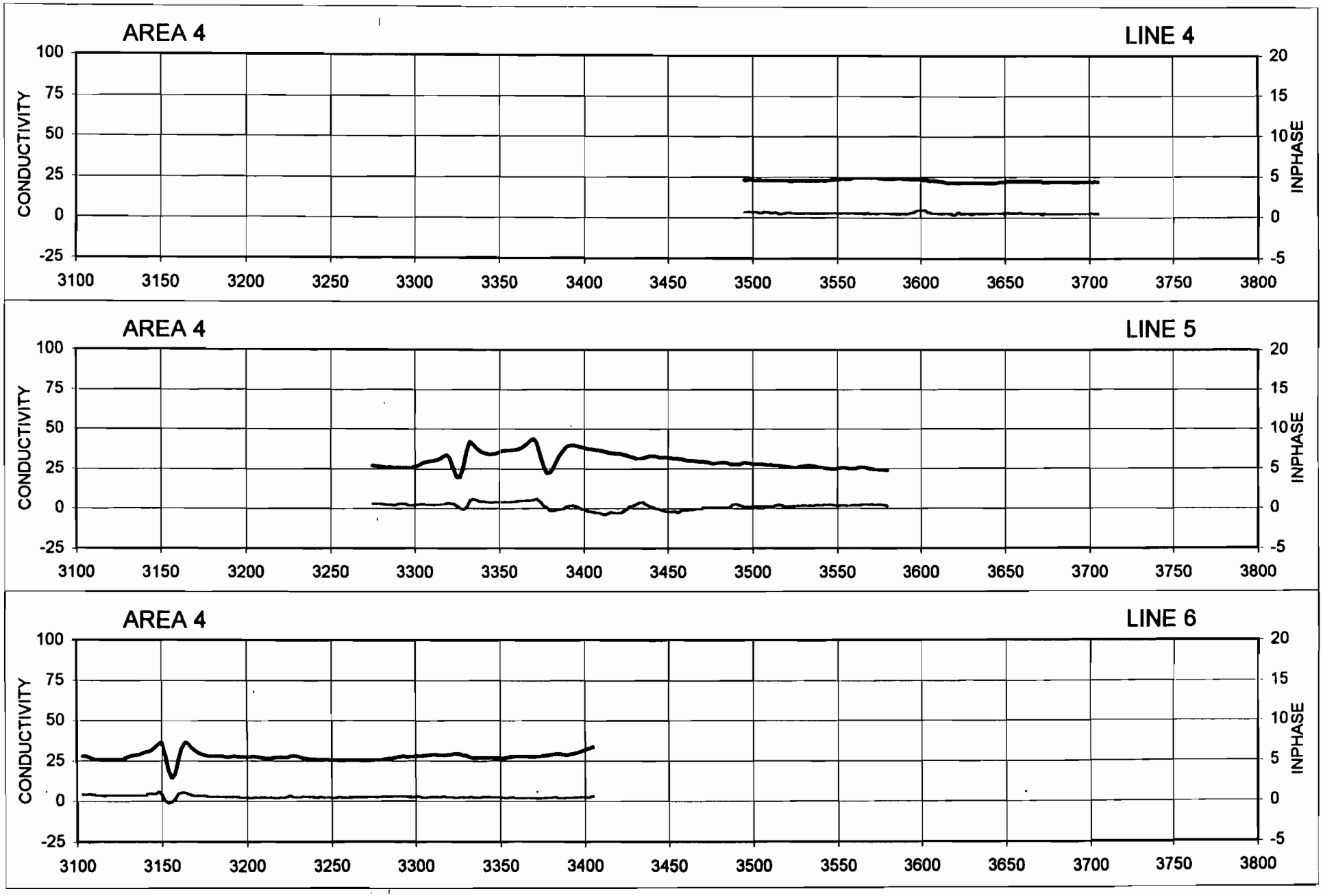
GEOSPHERE MIDWEST

FIGURE E-14



GEOSPHERE MIDWEST

FIGURE E-15



GEOSPHERE MIDWEST

FIGURE E-16

APPENDIX F

SITE 4: EM34 PROFILE DATA

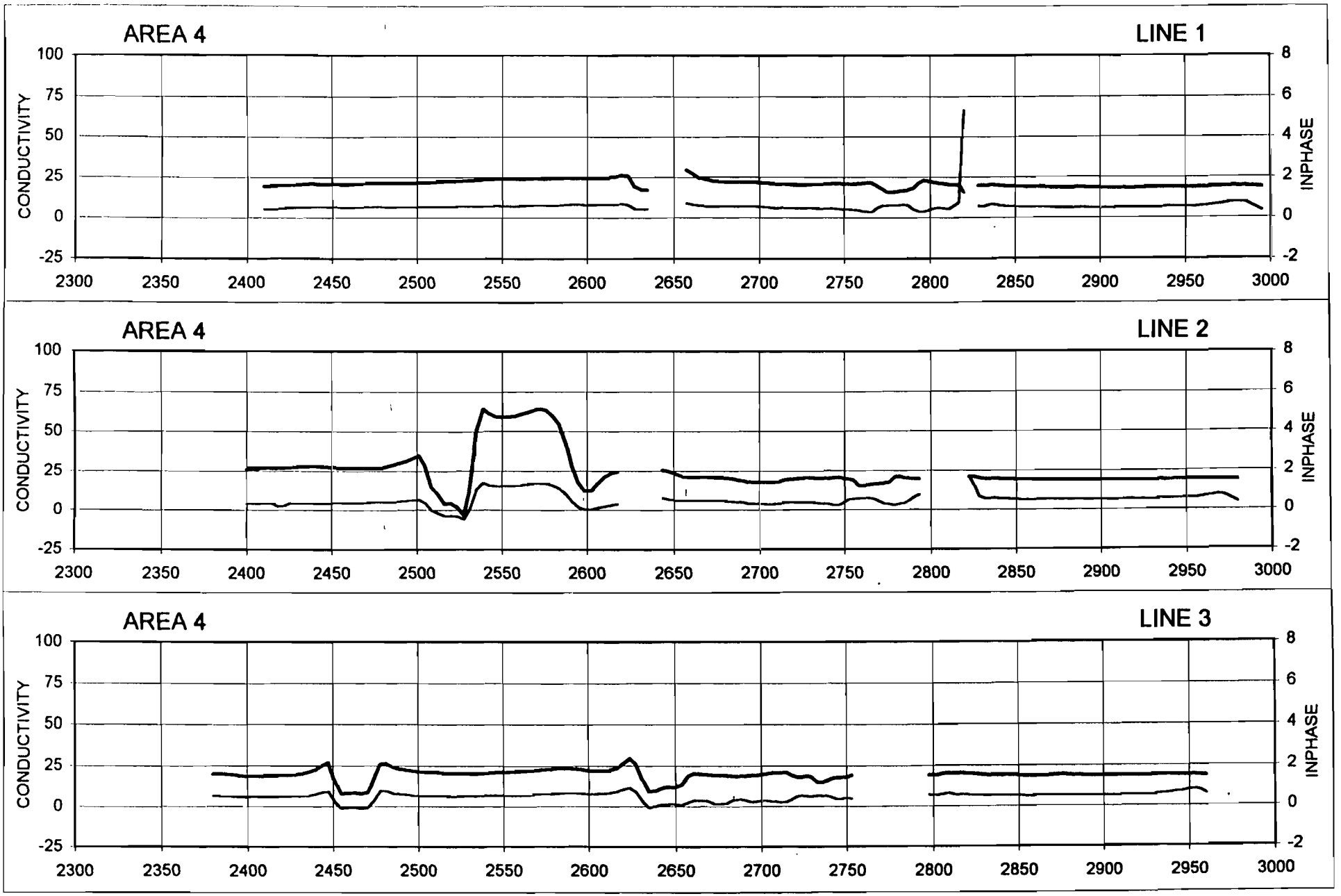
This appendix is a compilation of all EM34 profile data obtained at Site 4. Locations of these EM lines are given in Figure 4.2. The following profiles include line number, conductivity and inphase (vertical) scales and station location labels (in easting/northing coordinates). Conductivity values are given in millimhos/meter (mmhos/m), inphase values are given in parts per thousand (ppt) and location coordinates are in feet.

F1. EM34 SURVEY: SW-NE PROFILES FROM SITE 4

Figure F-1

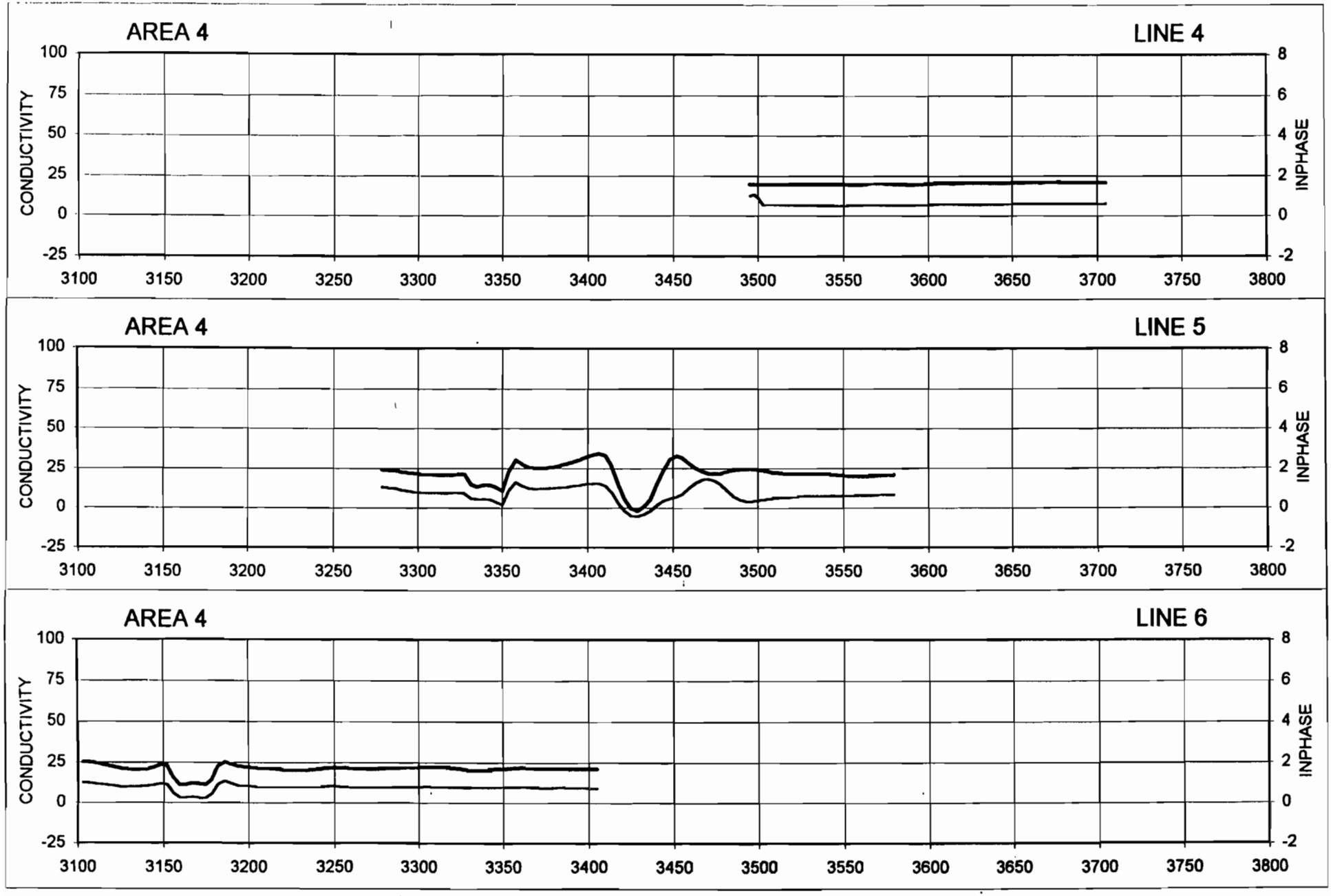
F2. EM34 SURVEY: SE-NW PROFILES FROM SITE 4

Figure F-2



GEOSPHERE MIDWEST

FIGURE F-1



GEOSPHERE MIDWEST

URE F-2

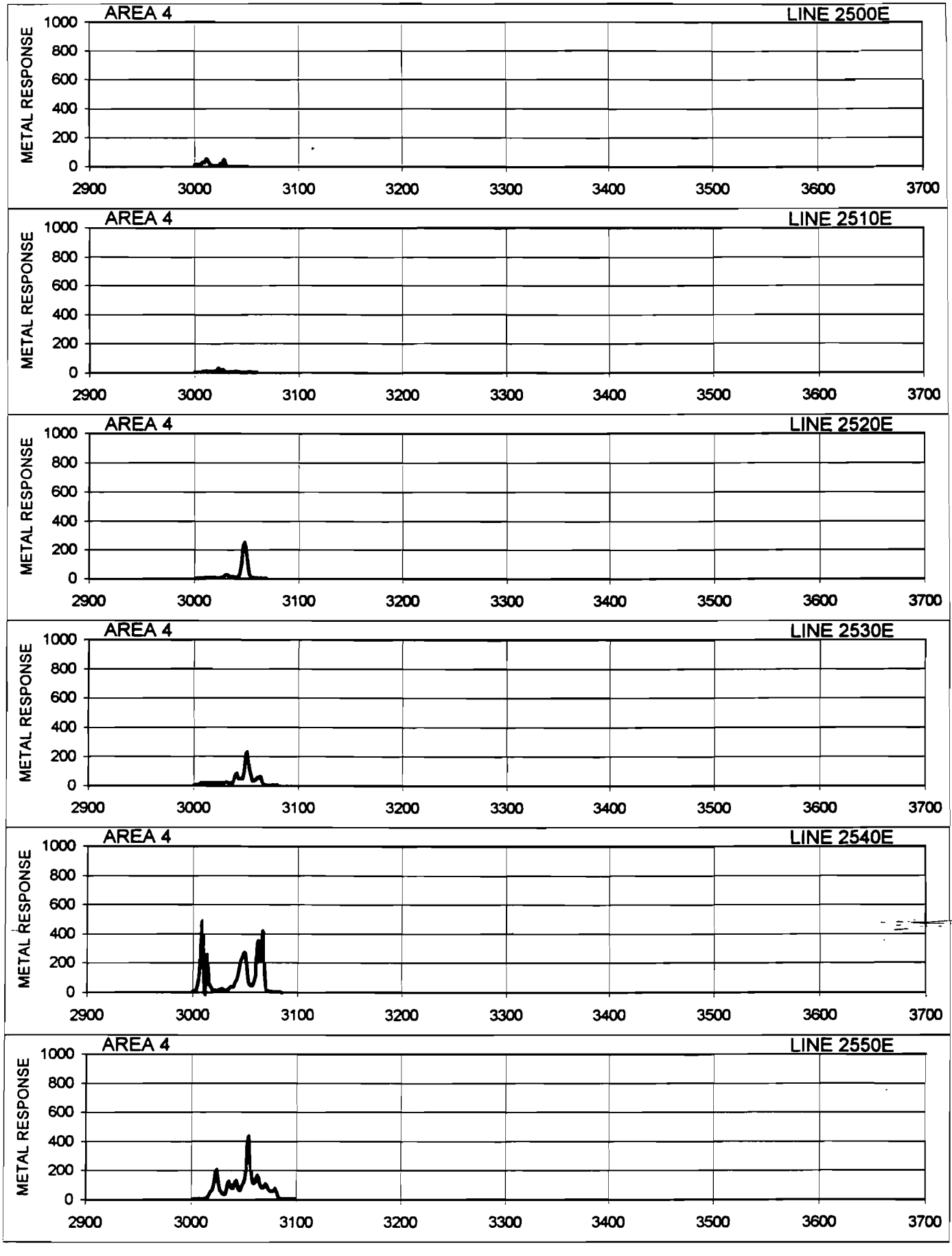
APPENDIX G

SITE 4: EM61 PROFILE DATA

This appendix is a compilation of all EM61 profile data obtained at Site 4. Locations of these EM61 lines are given in Figure 4.3. The following profiles include line number (easting coordinate), metal response (vertical) scales and station location labels (northing coordinates). Metal response values are given in millivolts; location coordinates are in feet.

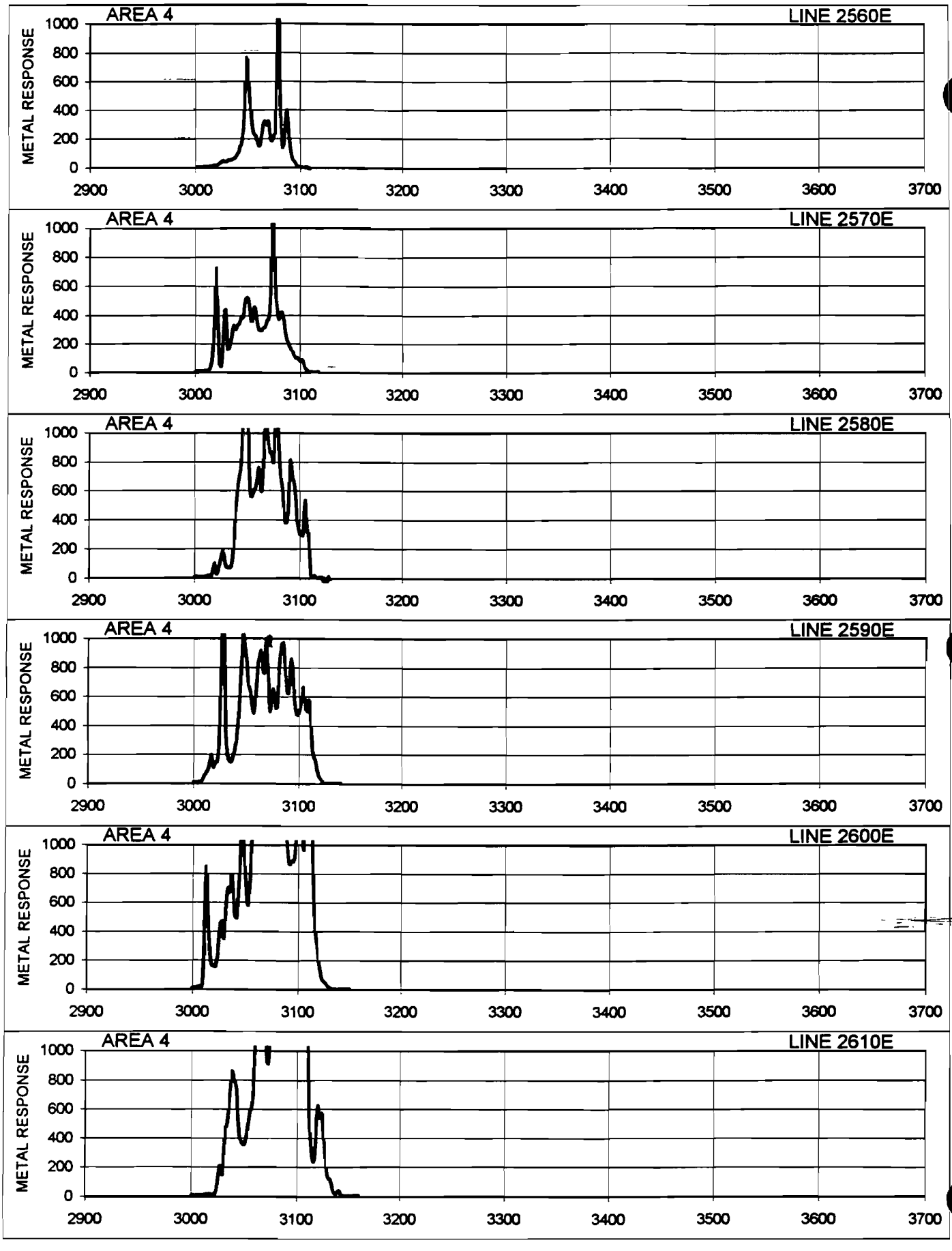
G1. EM61 SURVEY: N-S PROFILES FROM SITE 4

Figures G-1 to G-13.



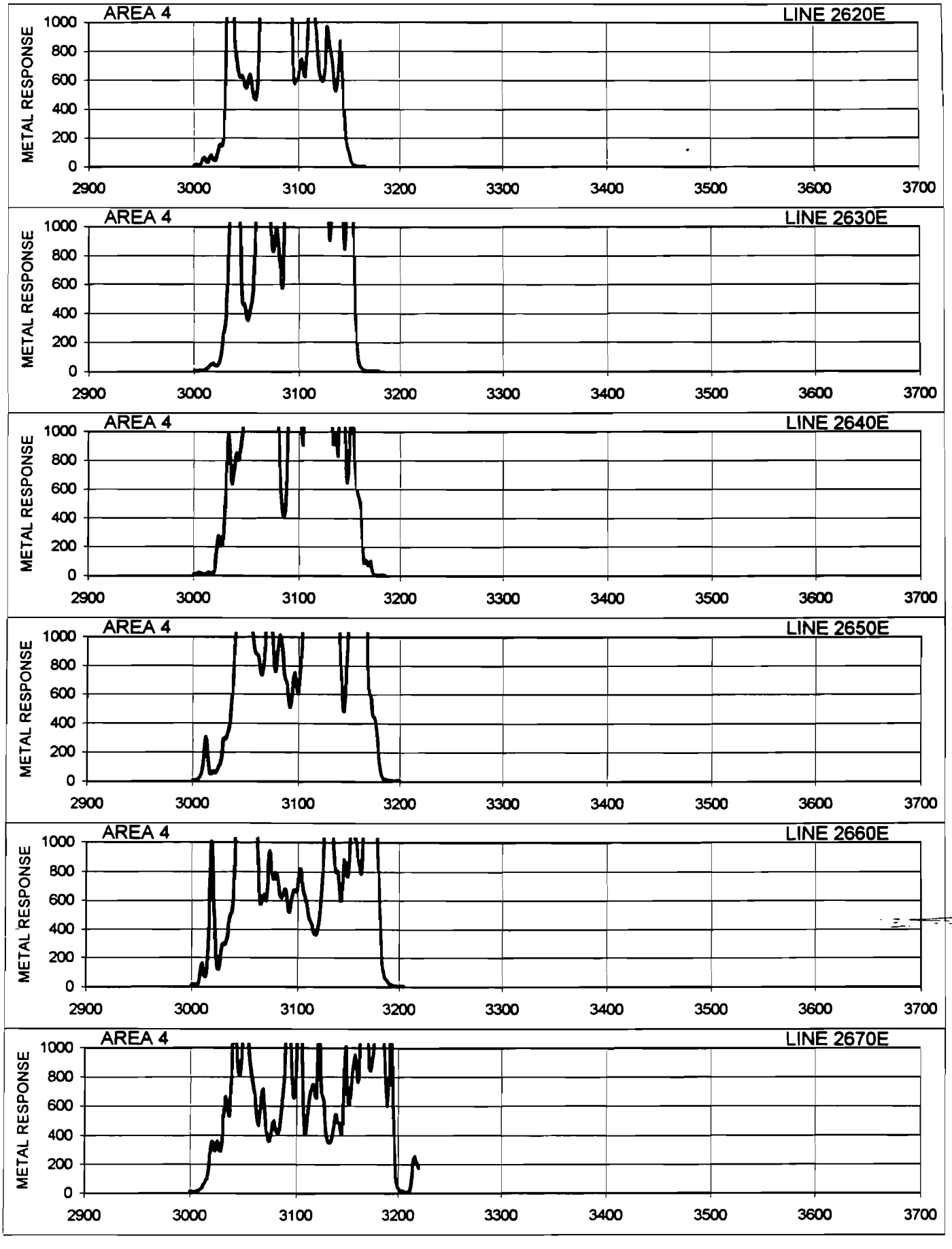
GEOSPHERE MIDWEST

FIGURE G-1



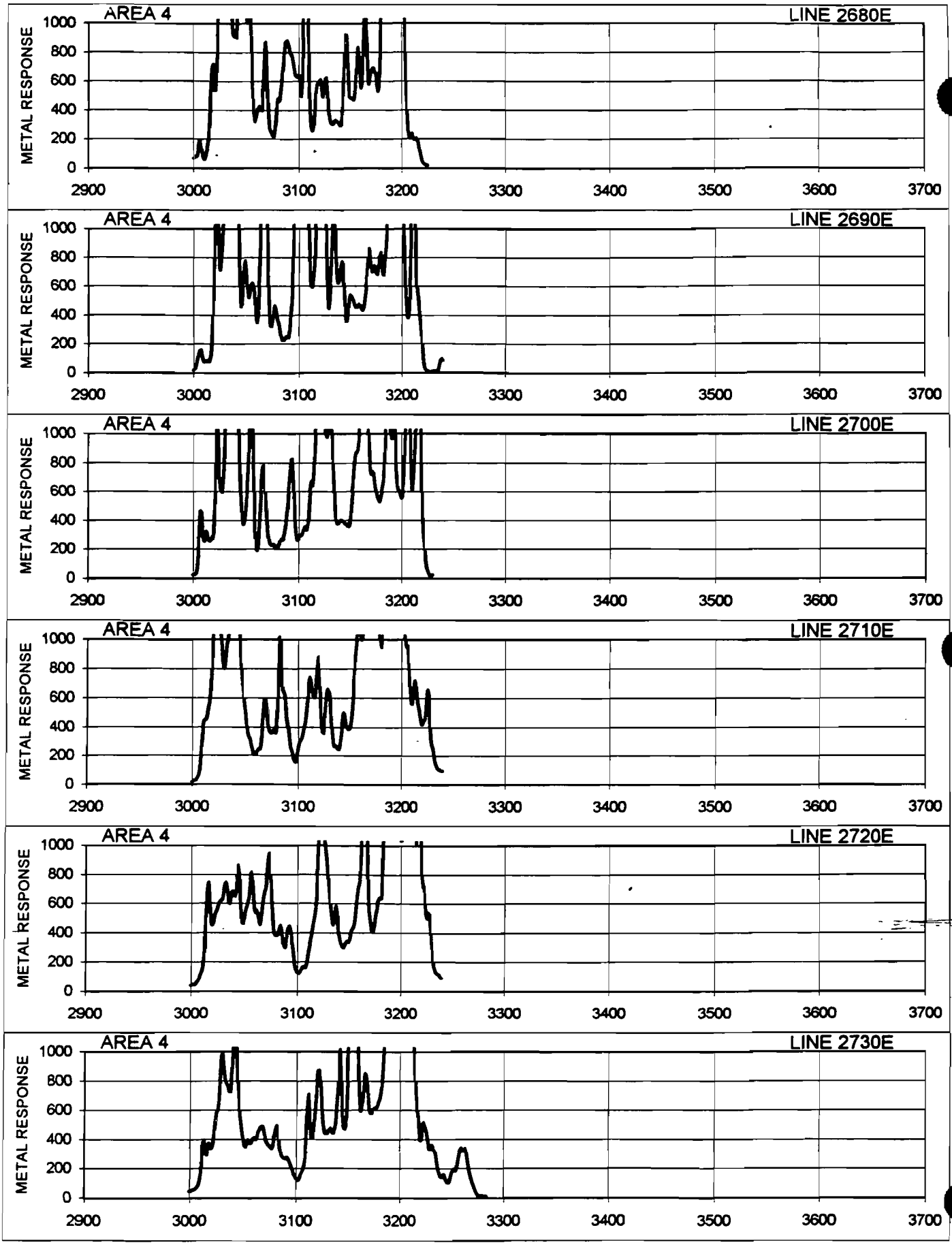
GEOSPHERE MIDWEST

FIGURE G-2



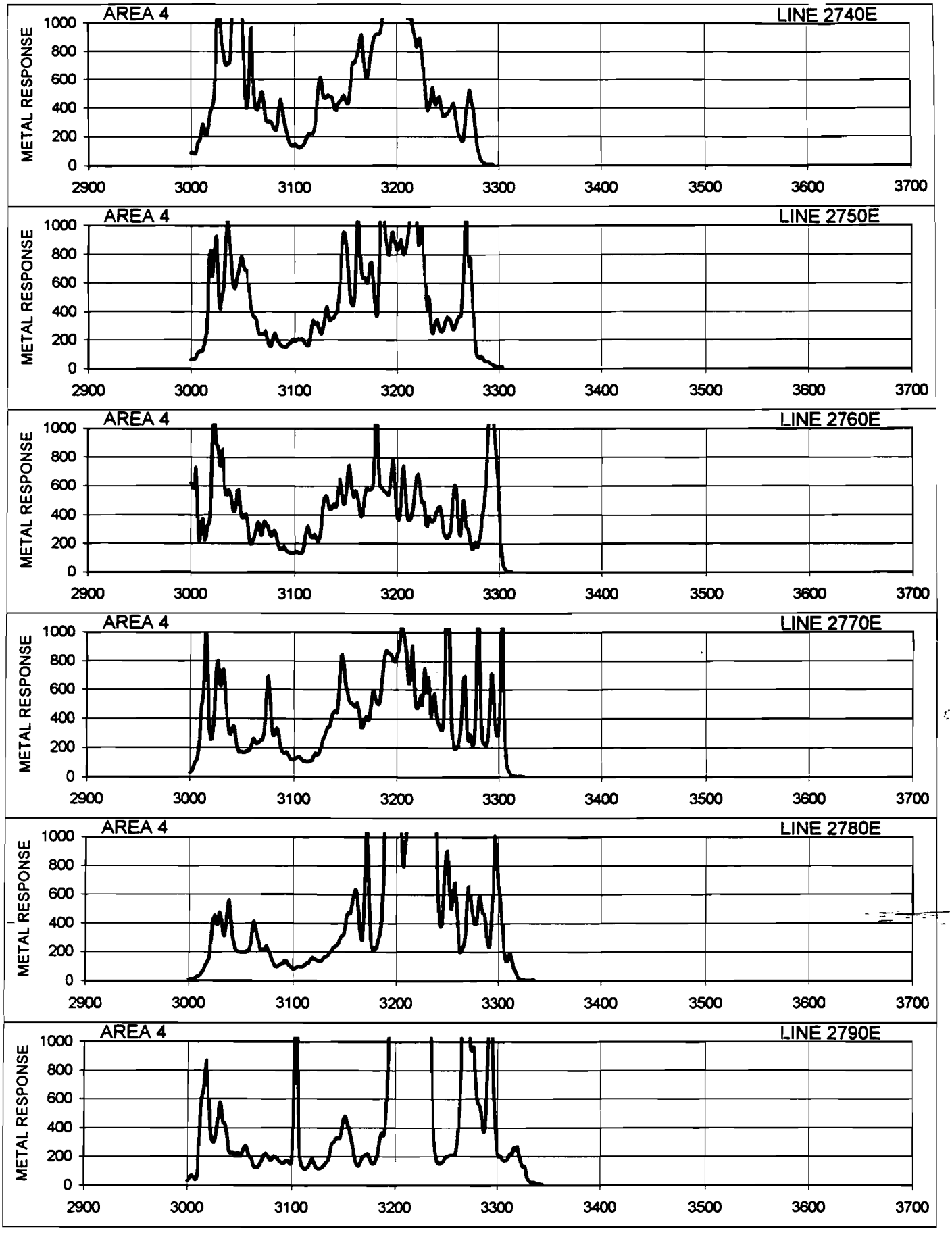
GEOSPHERE MIDWEST

FIGURE G-3



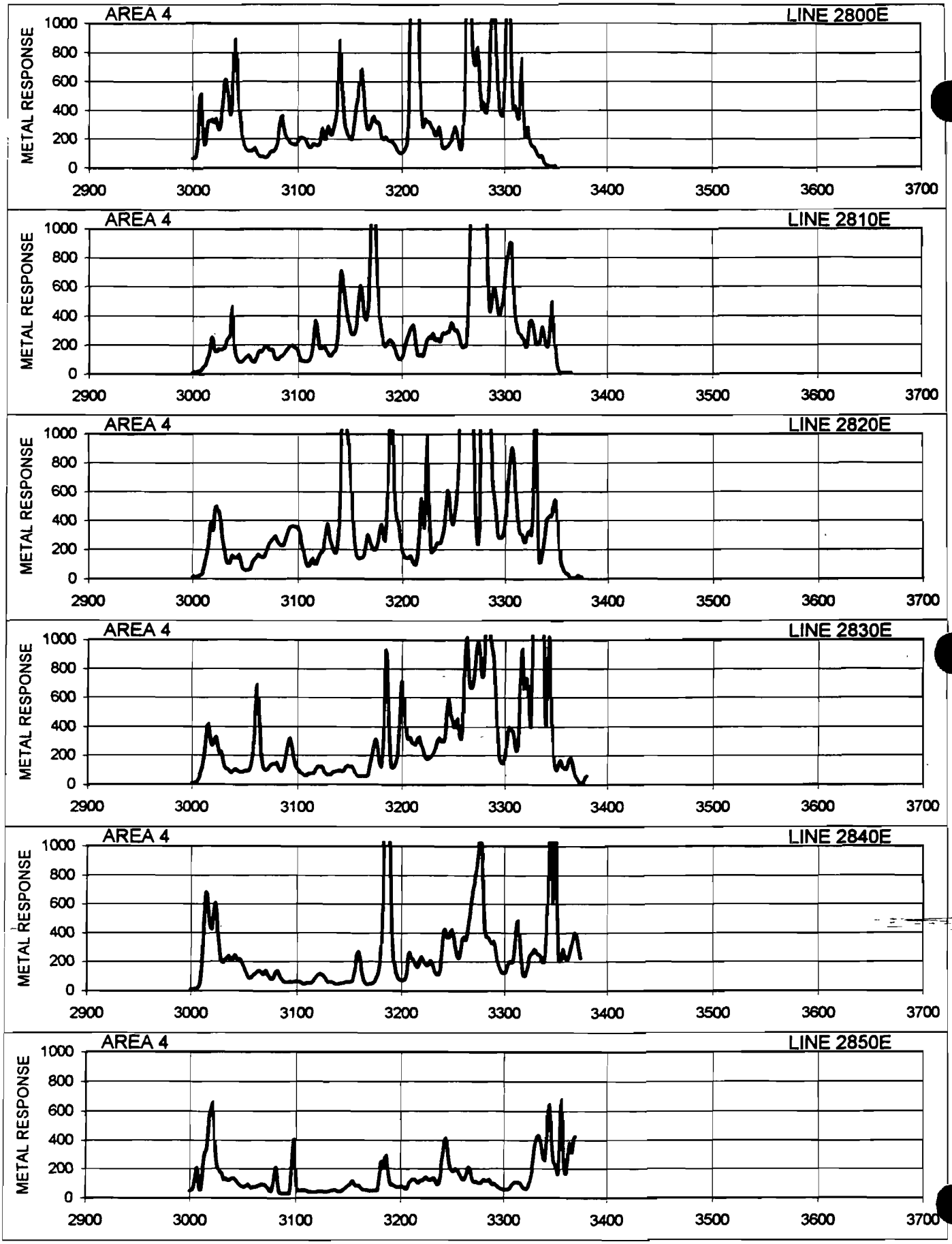
GEOSPHERE MIDWEST

FIGURE G-4



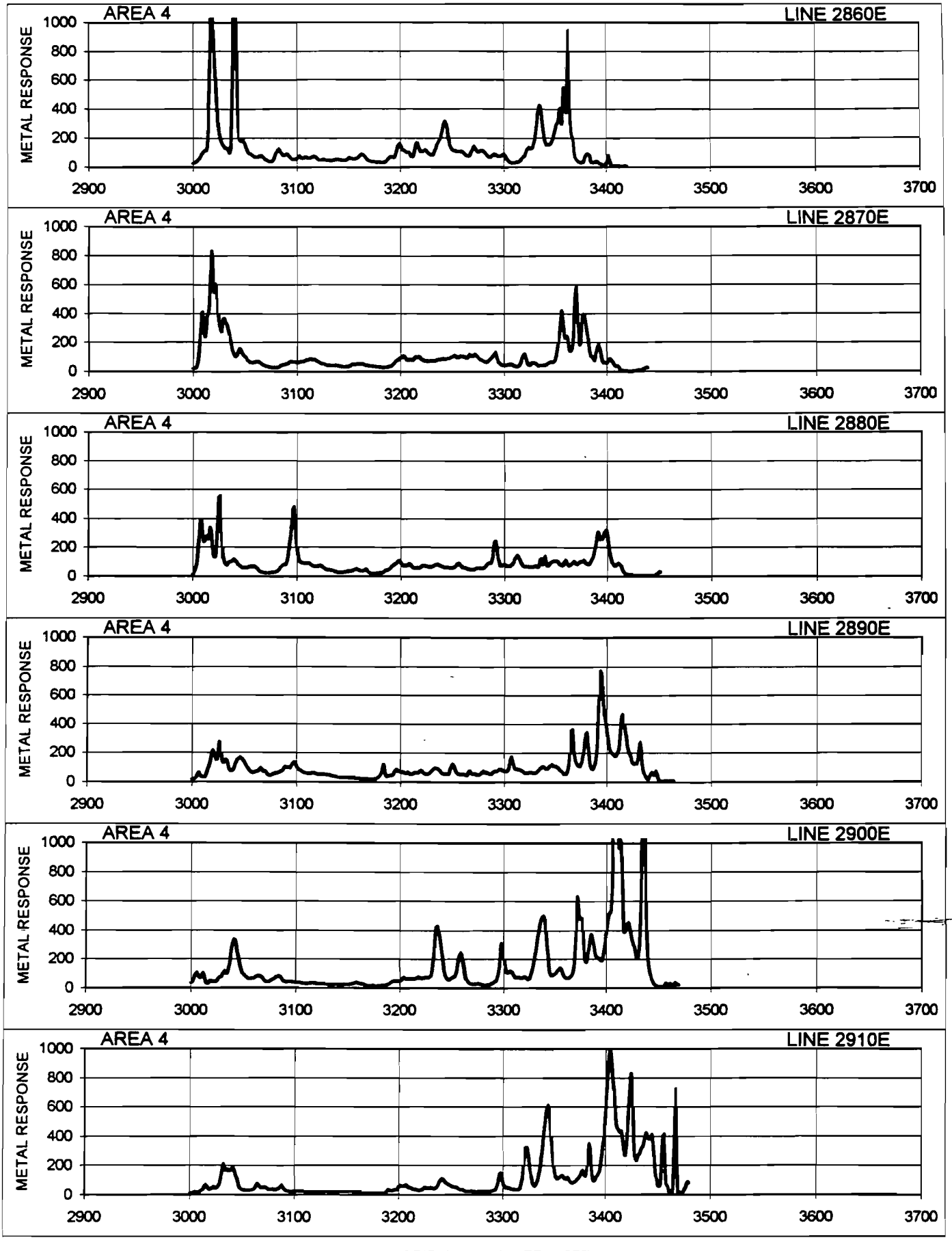
GEOSPHERE MIDWEST

FIGURE G-5



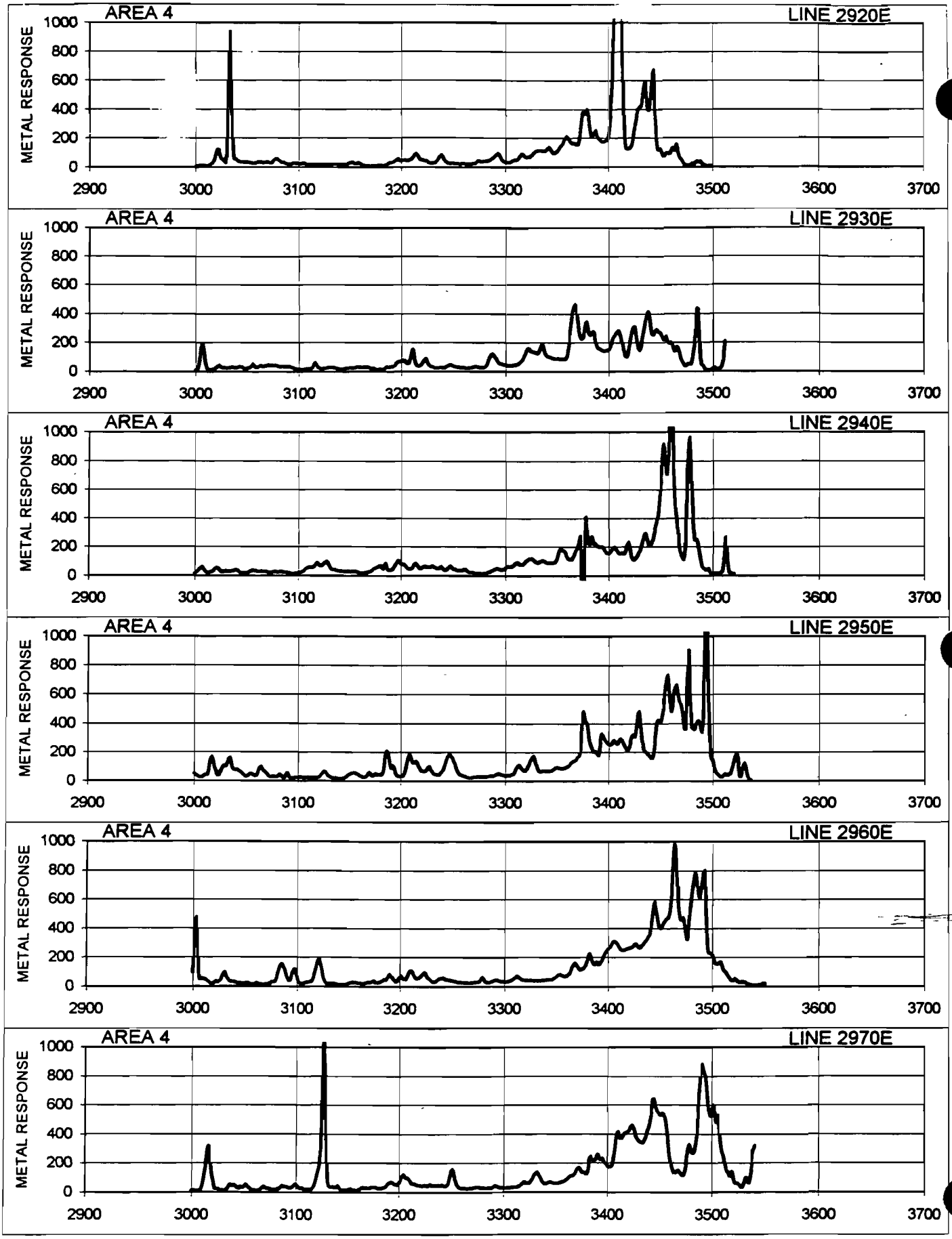
GEOSPHERE MIDWEST

FIGURE G-6



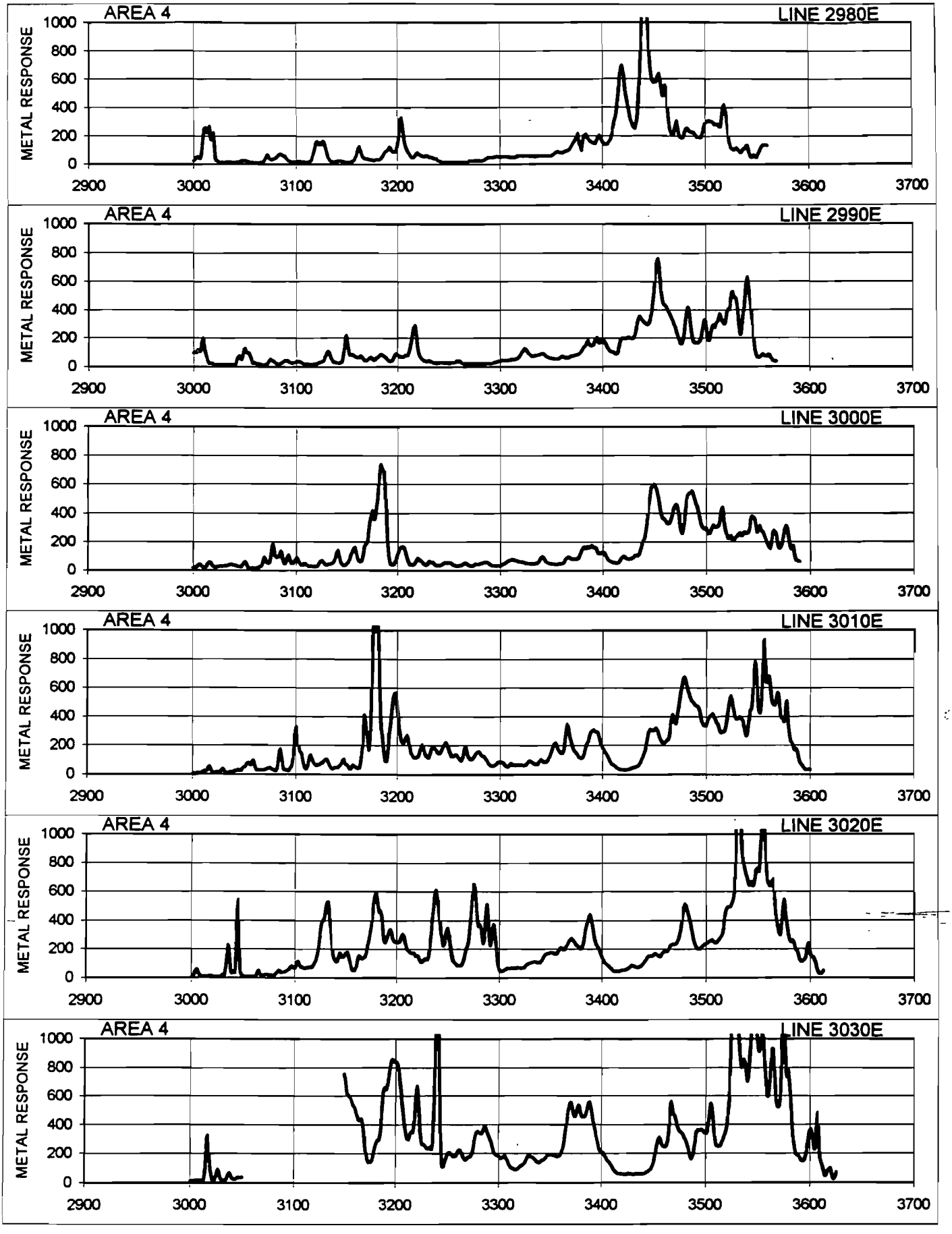
GEOSPHERE MIDWEST

FIGURE G-7



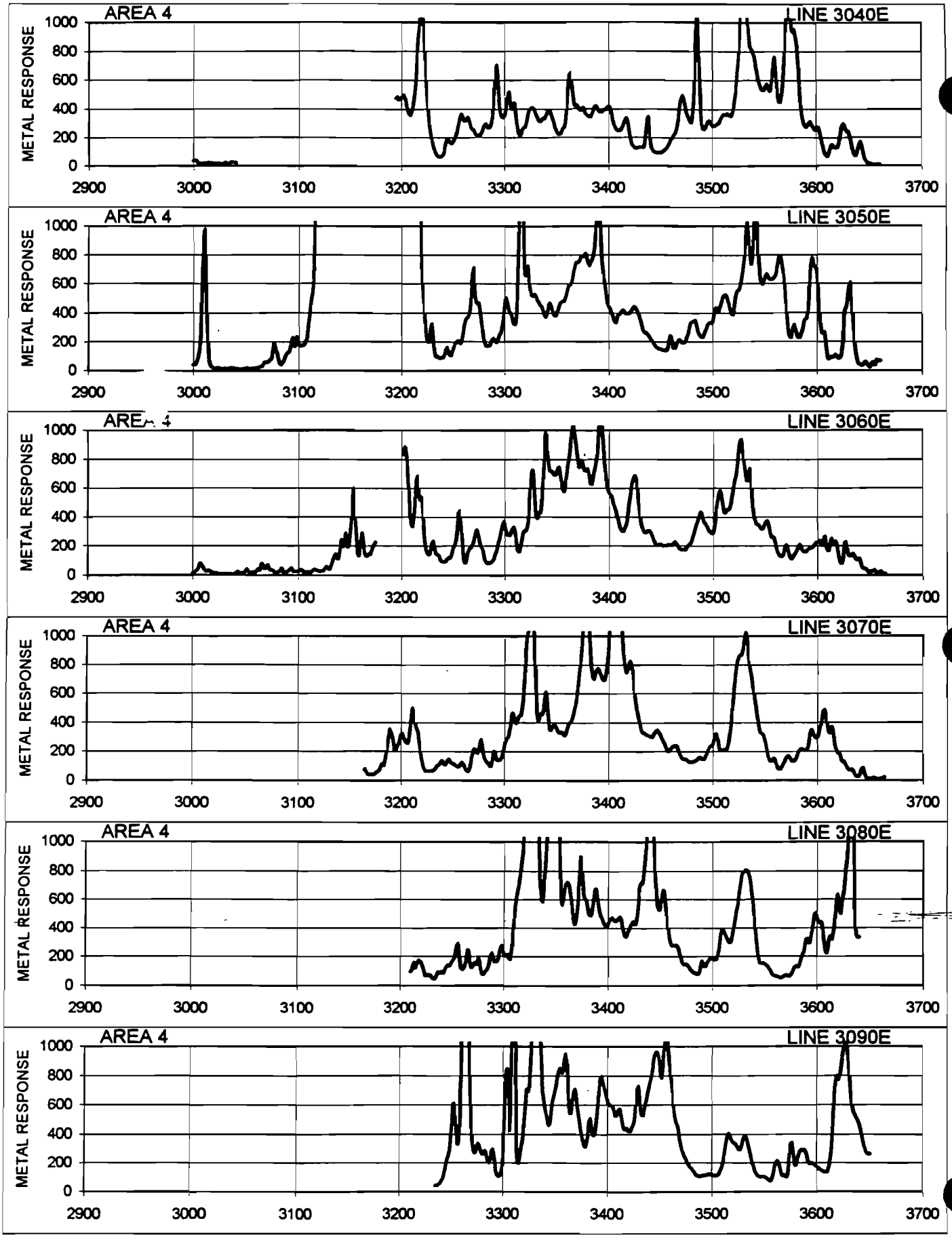
GEOSPHERE MIDWEST

FIGURE G-8



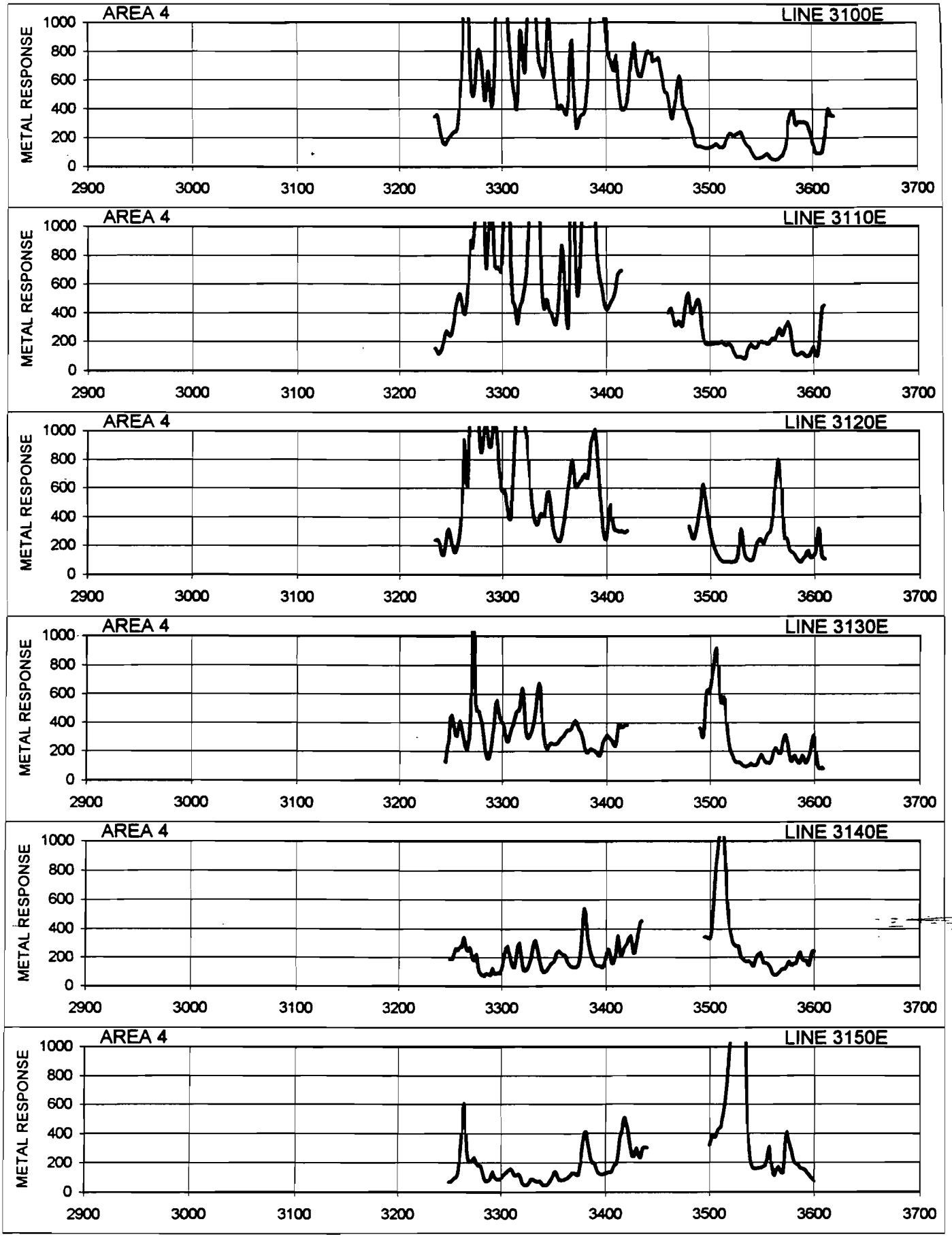
GEOSPHERE MIDWEST

FIGURE G-9



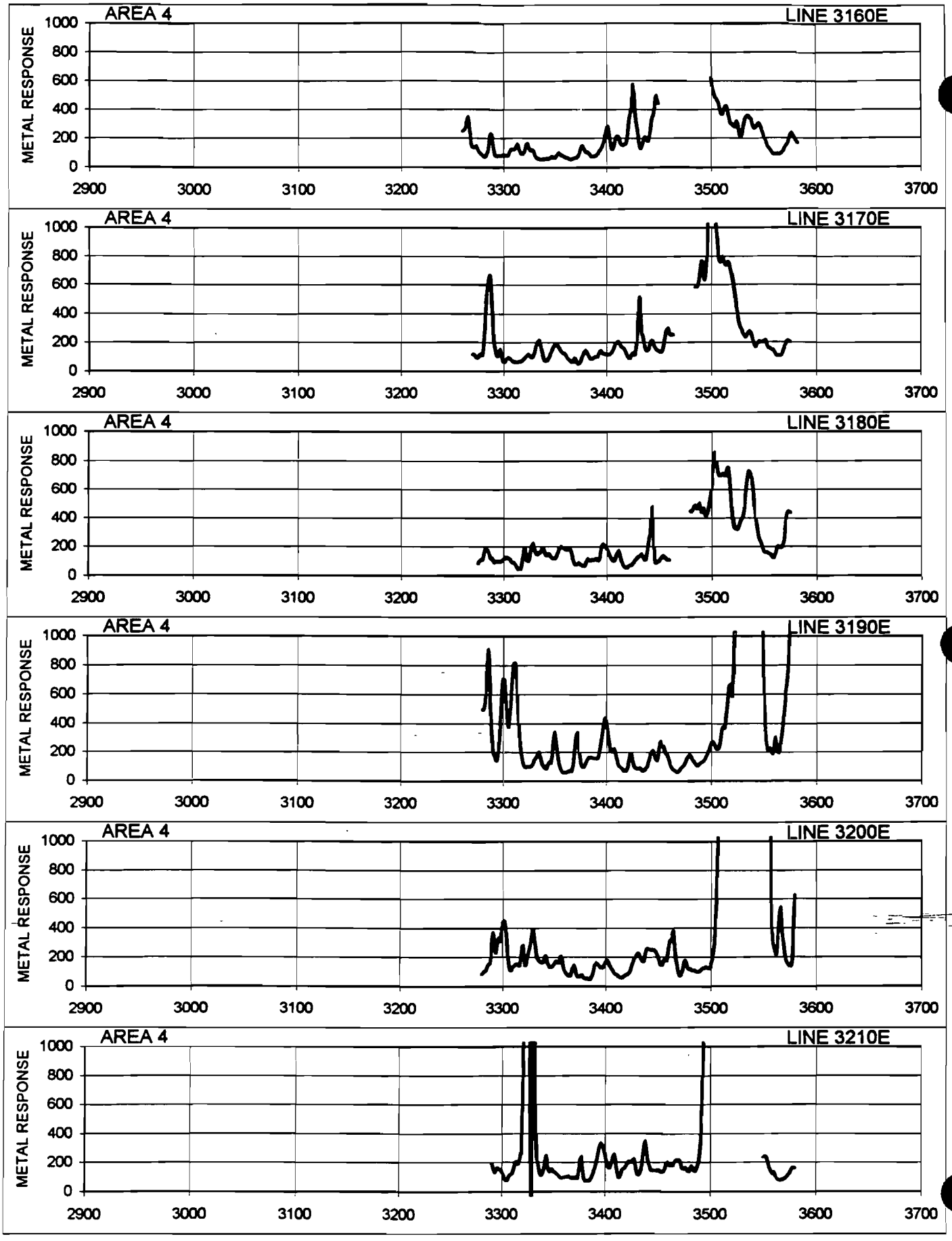
GEOSPHERE MIDWEST

FIGURE G-10



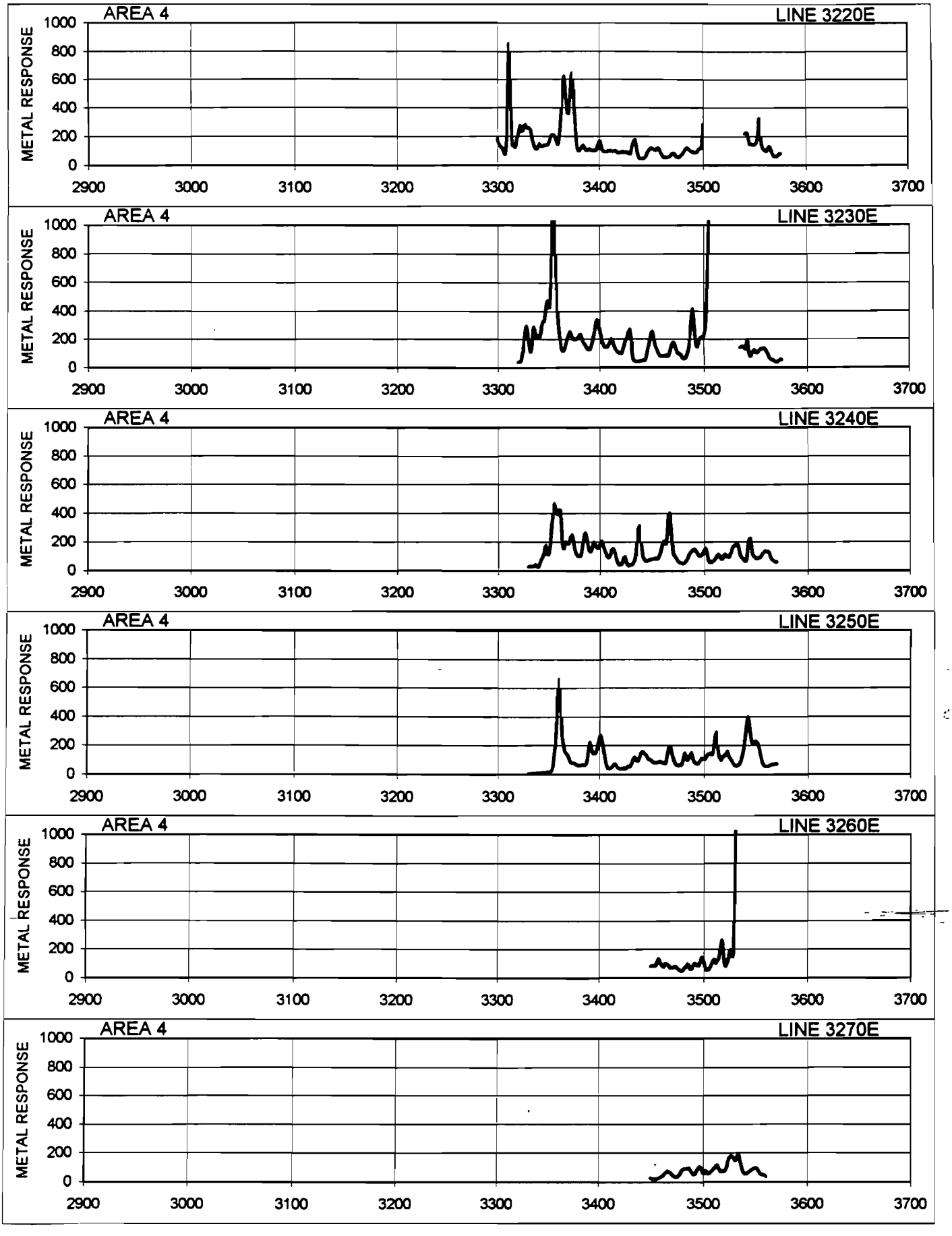
GEOSPHERE MIDWEST

FIGURE G-11



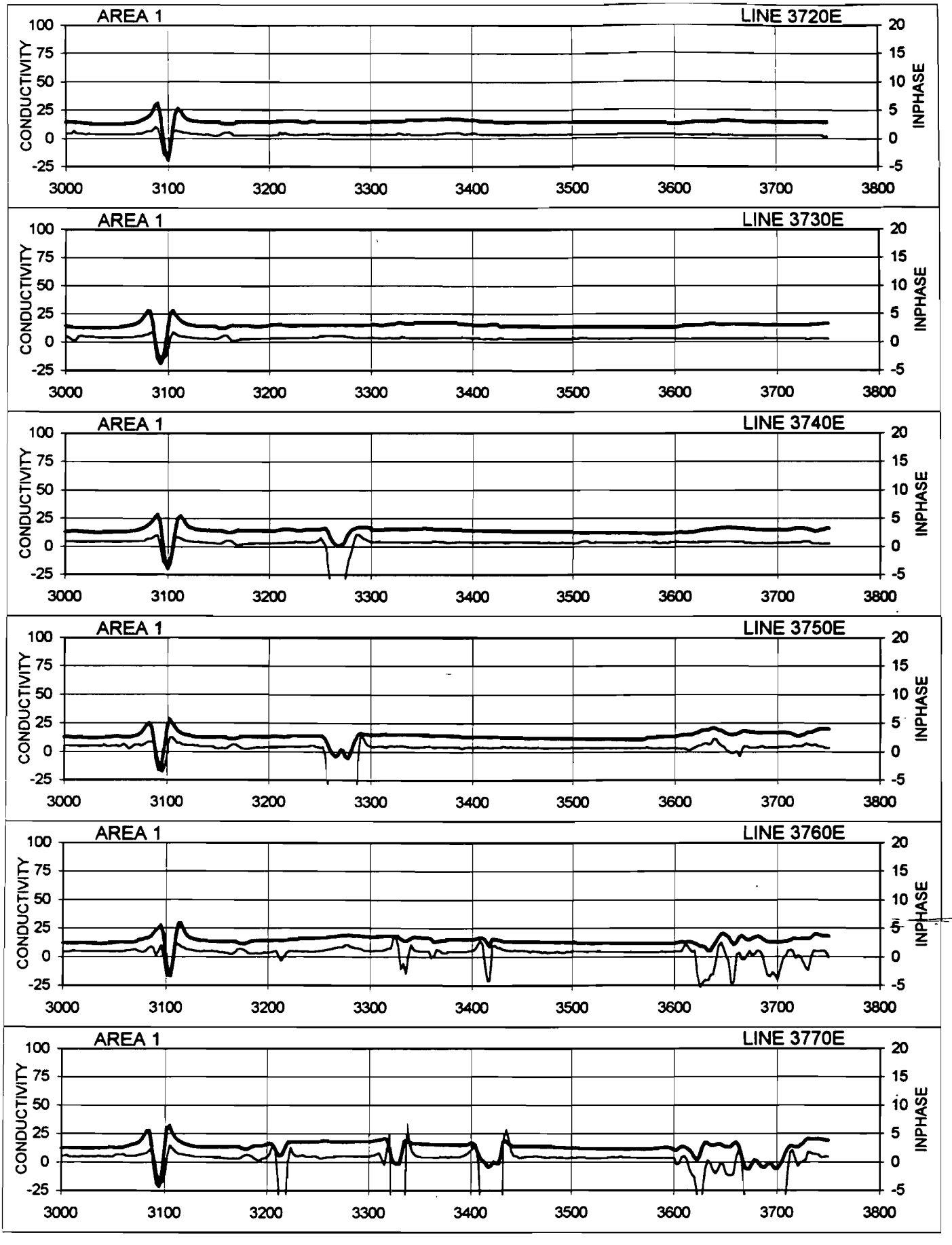
GEOSPHERE MIDWEST

FIGURE G-12



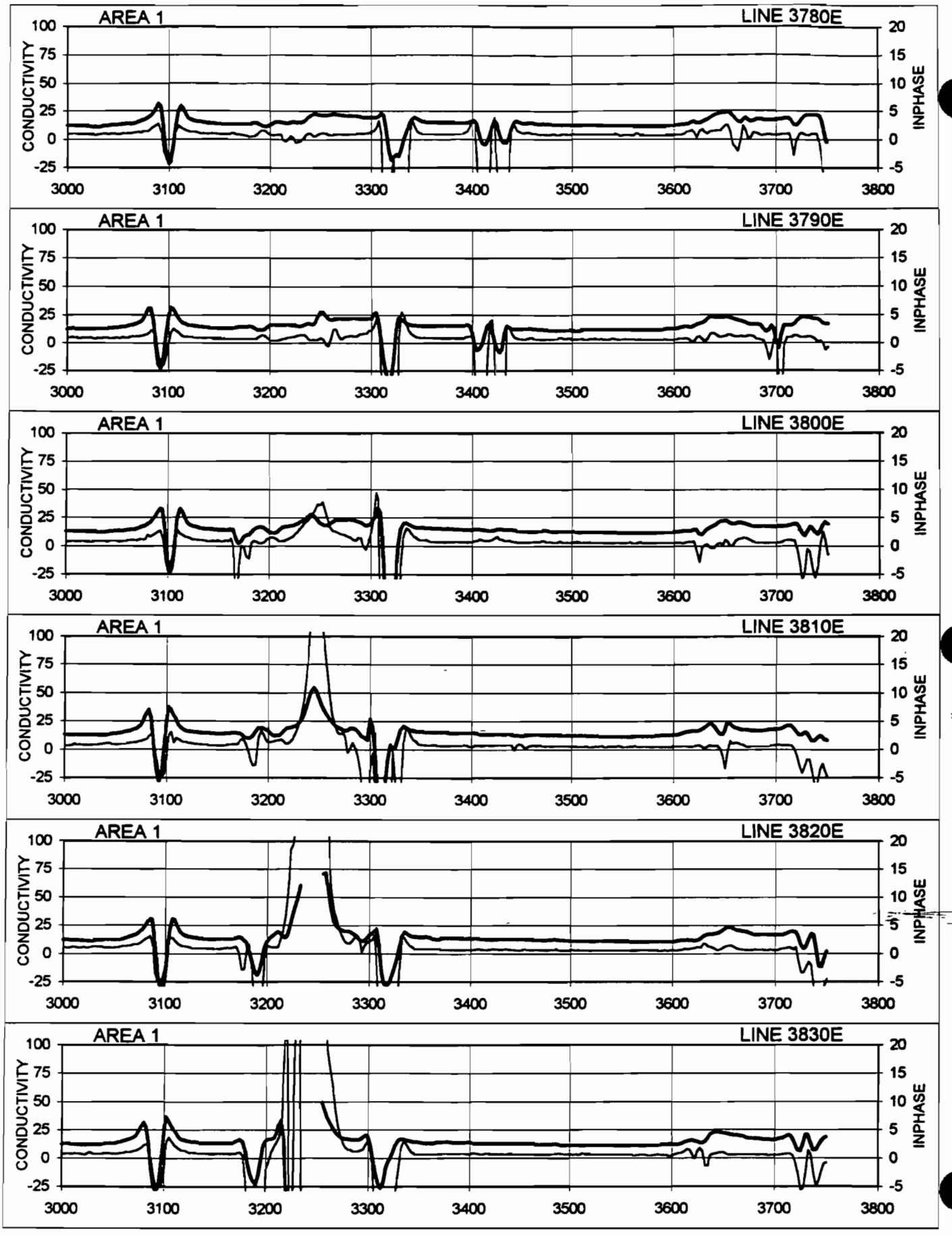
GEOSPHERE MIDWEST

FIGURE G-13



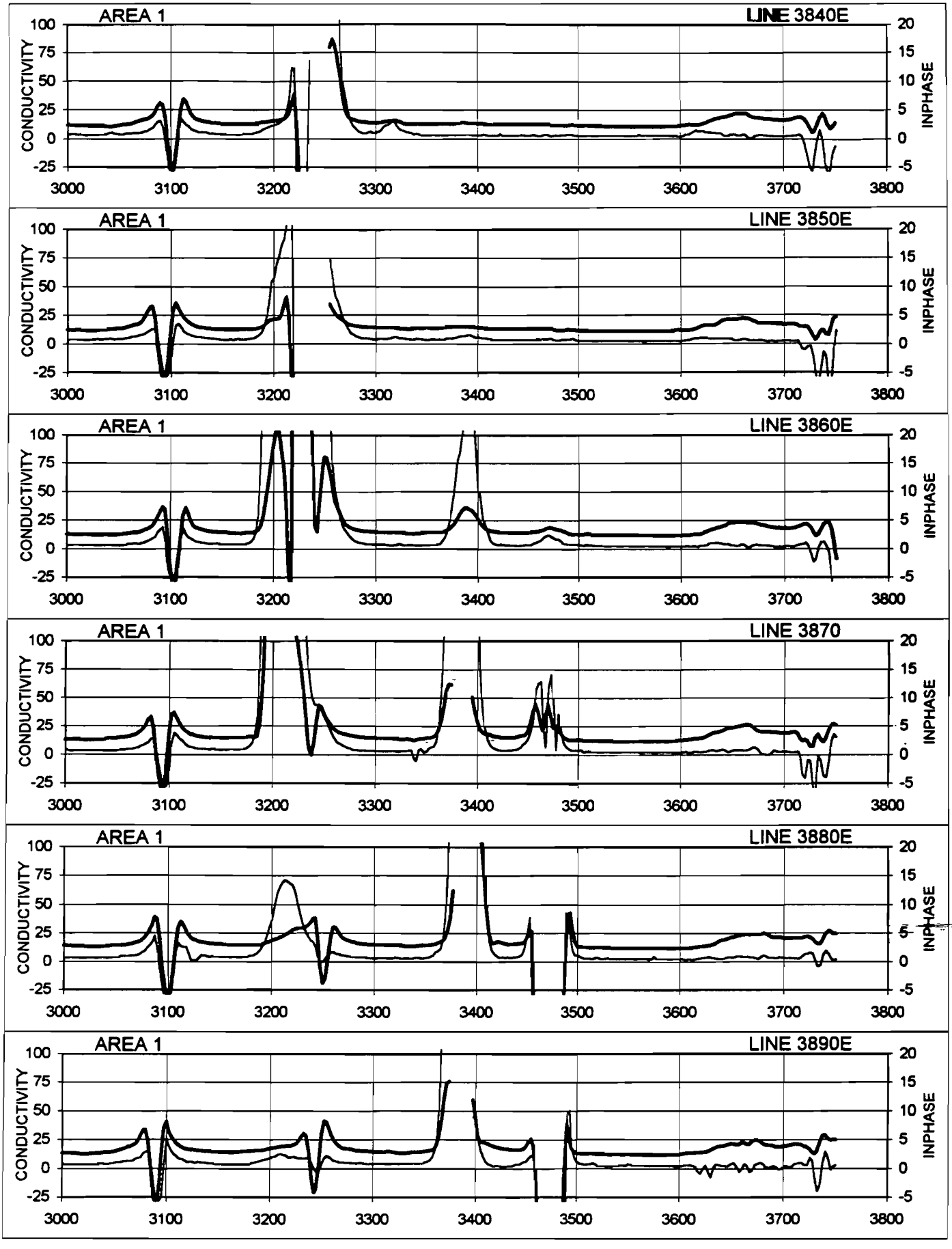
GEOSPHERE MIDWEST

FIGURE B-3



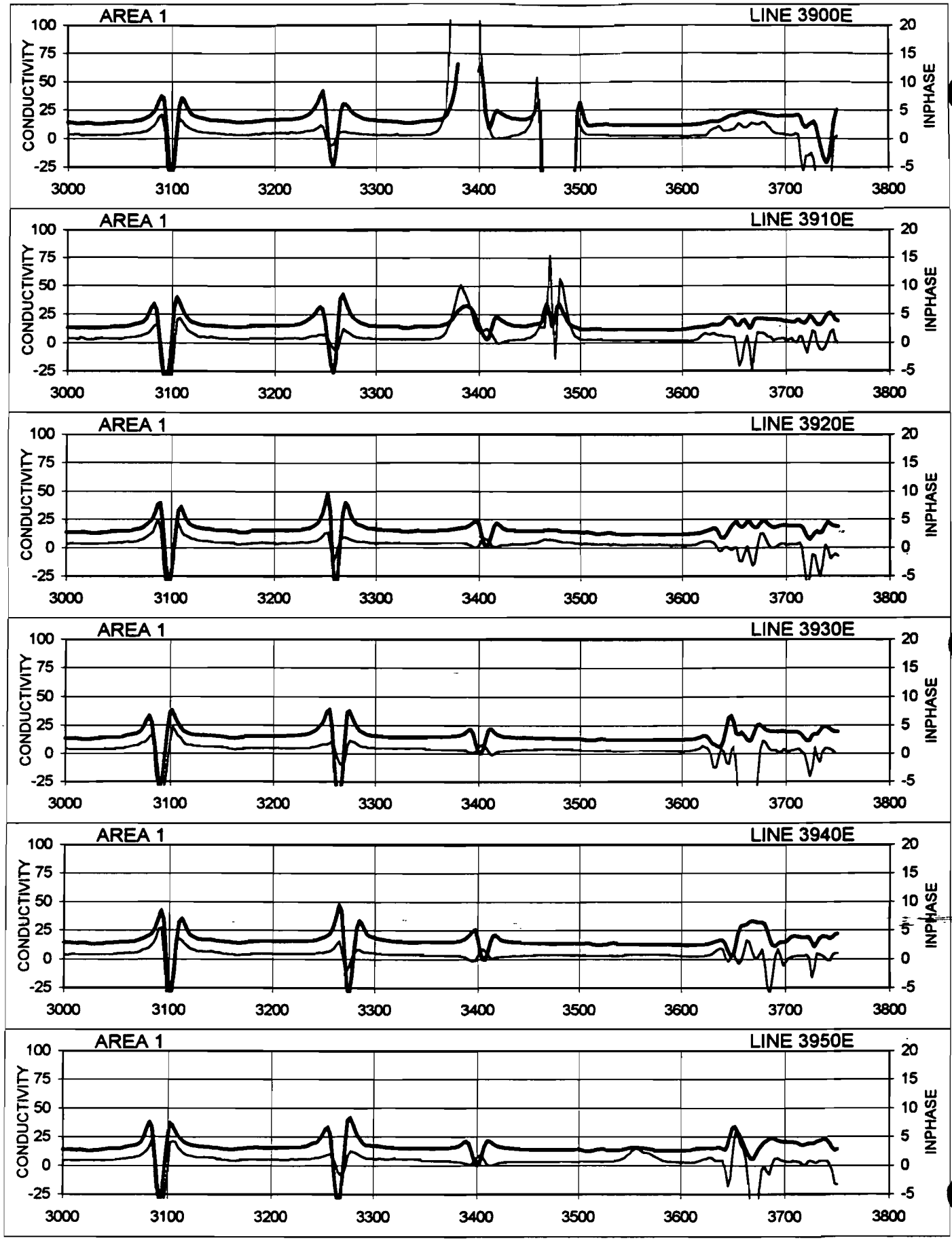
GEOSPHERE MIDWEST

FIGURE B-4



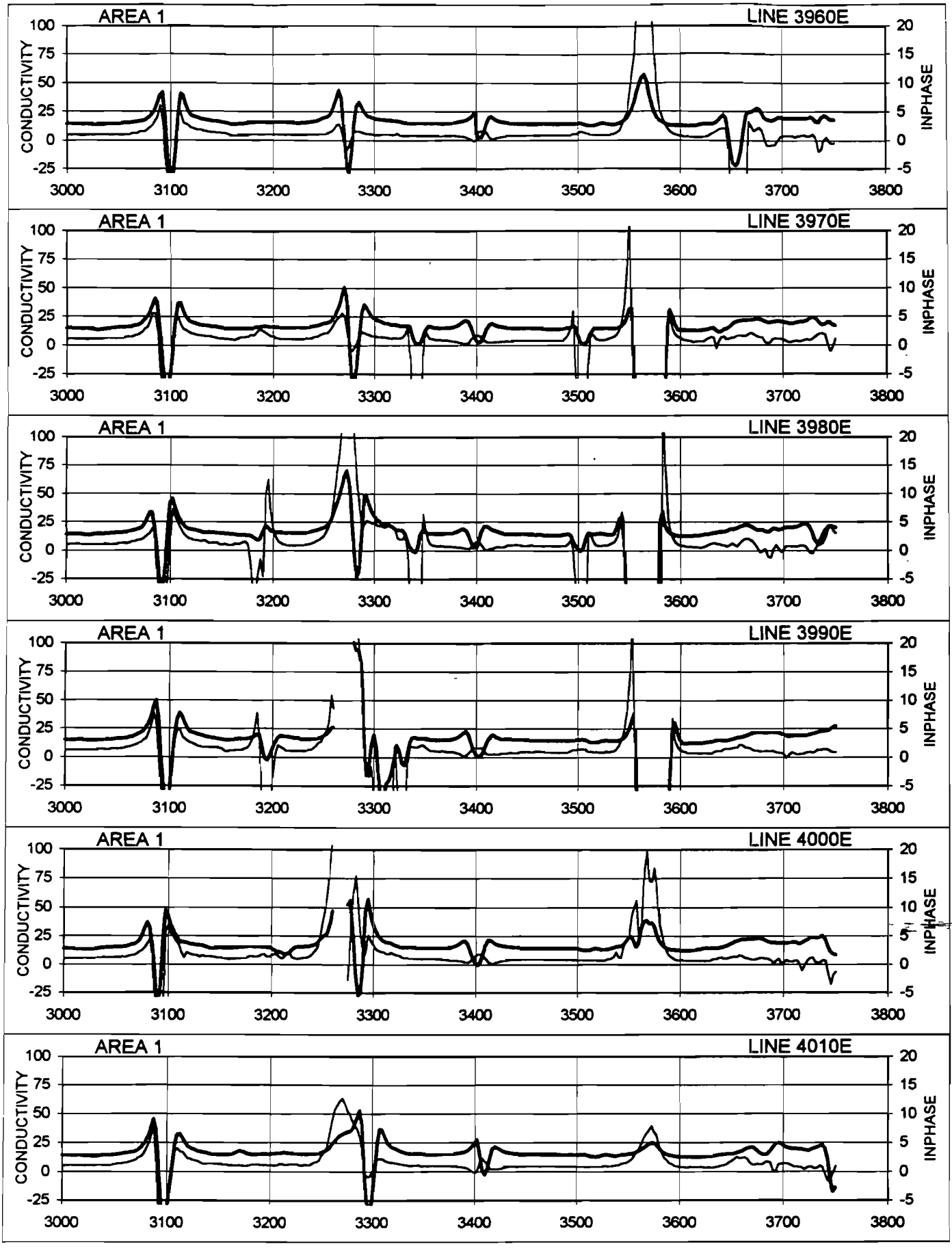
GEOSPHERE MIDWEST

FIGURE B-5



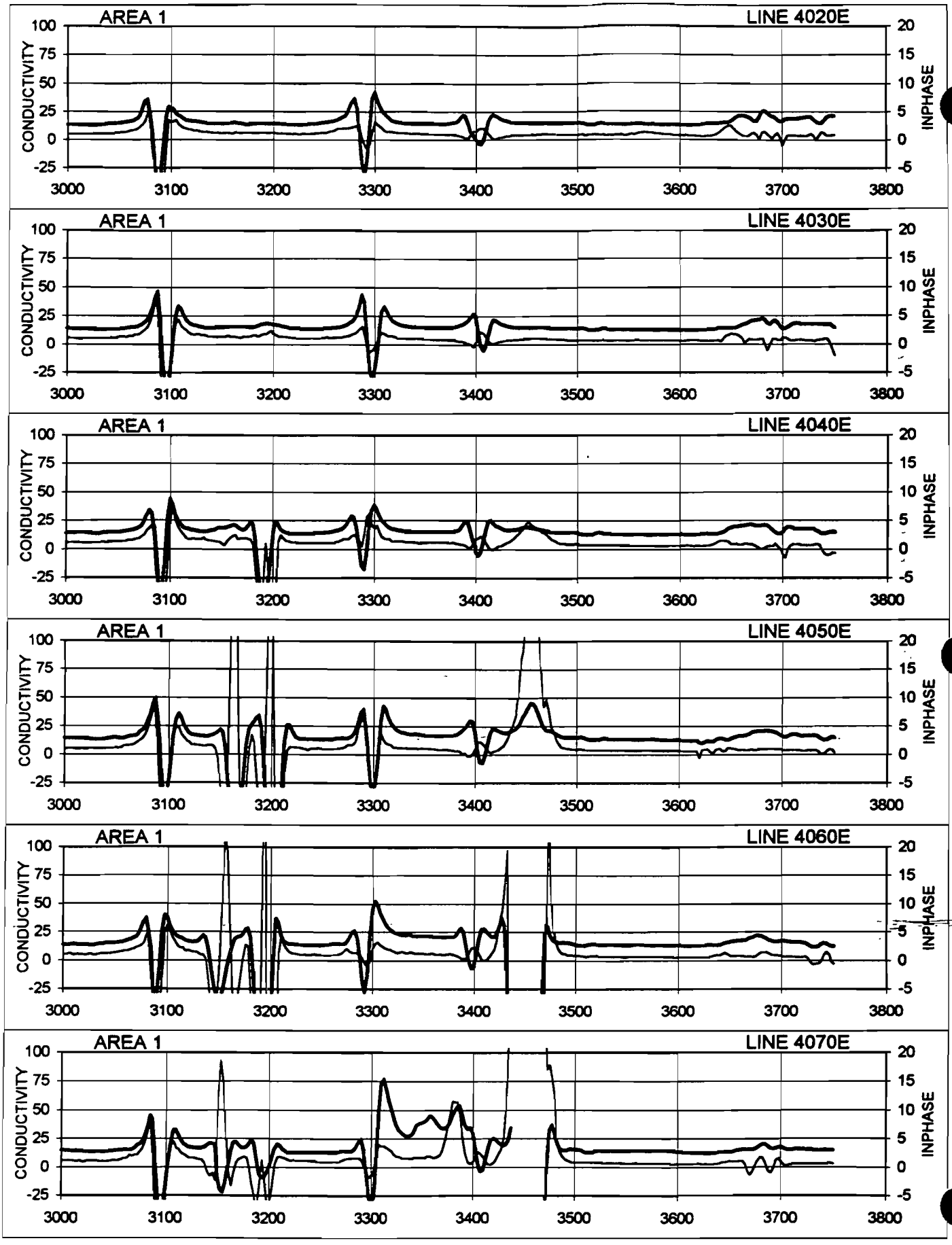
GEOSPHERE MIDWEST

FIGURE B-6



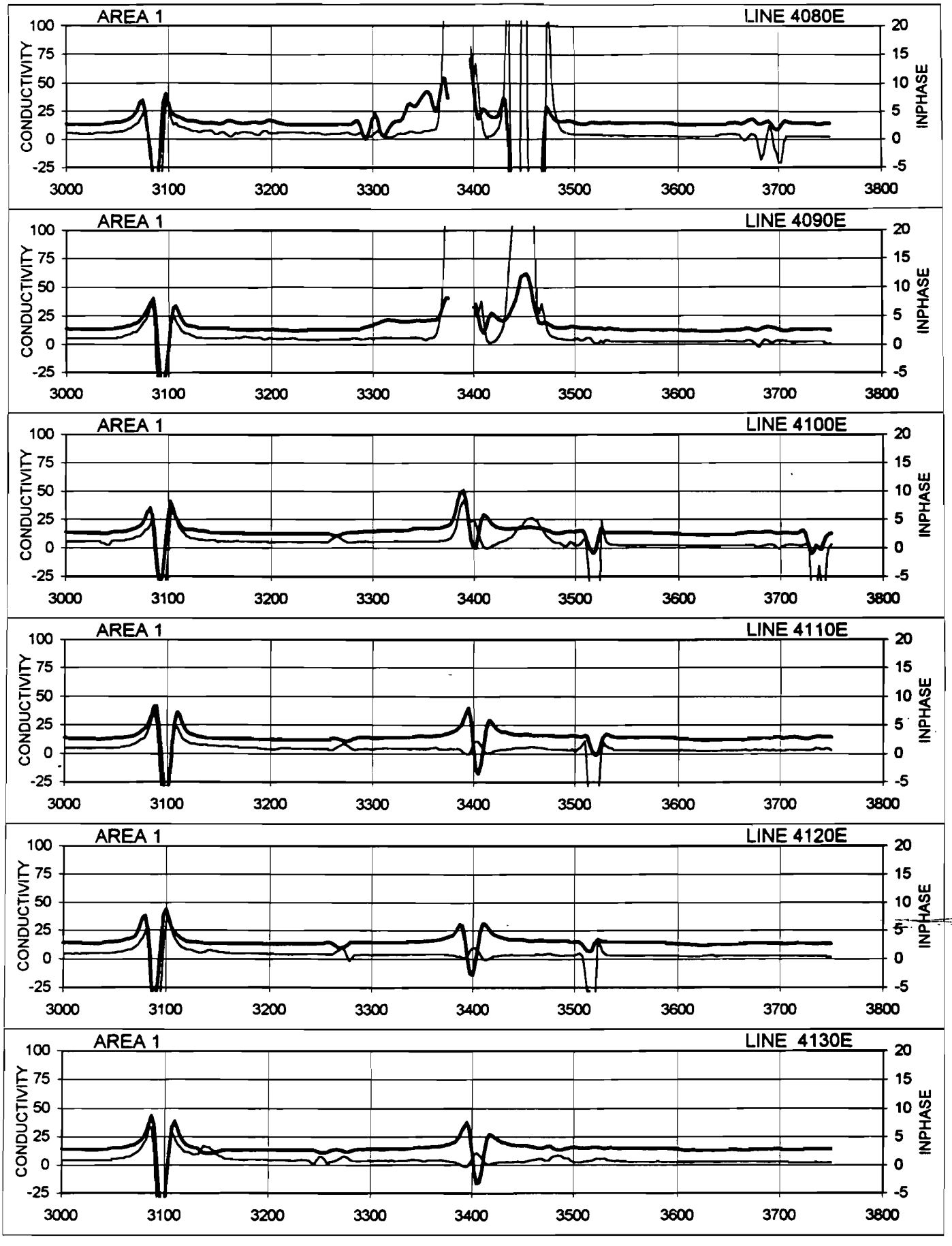
GEOSPHERE MIDWEST

FIGURE B-7



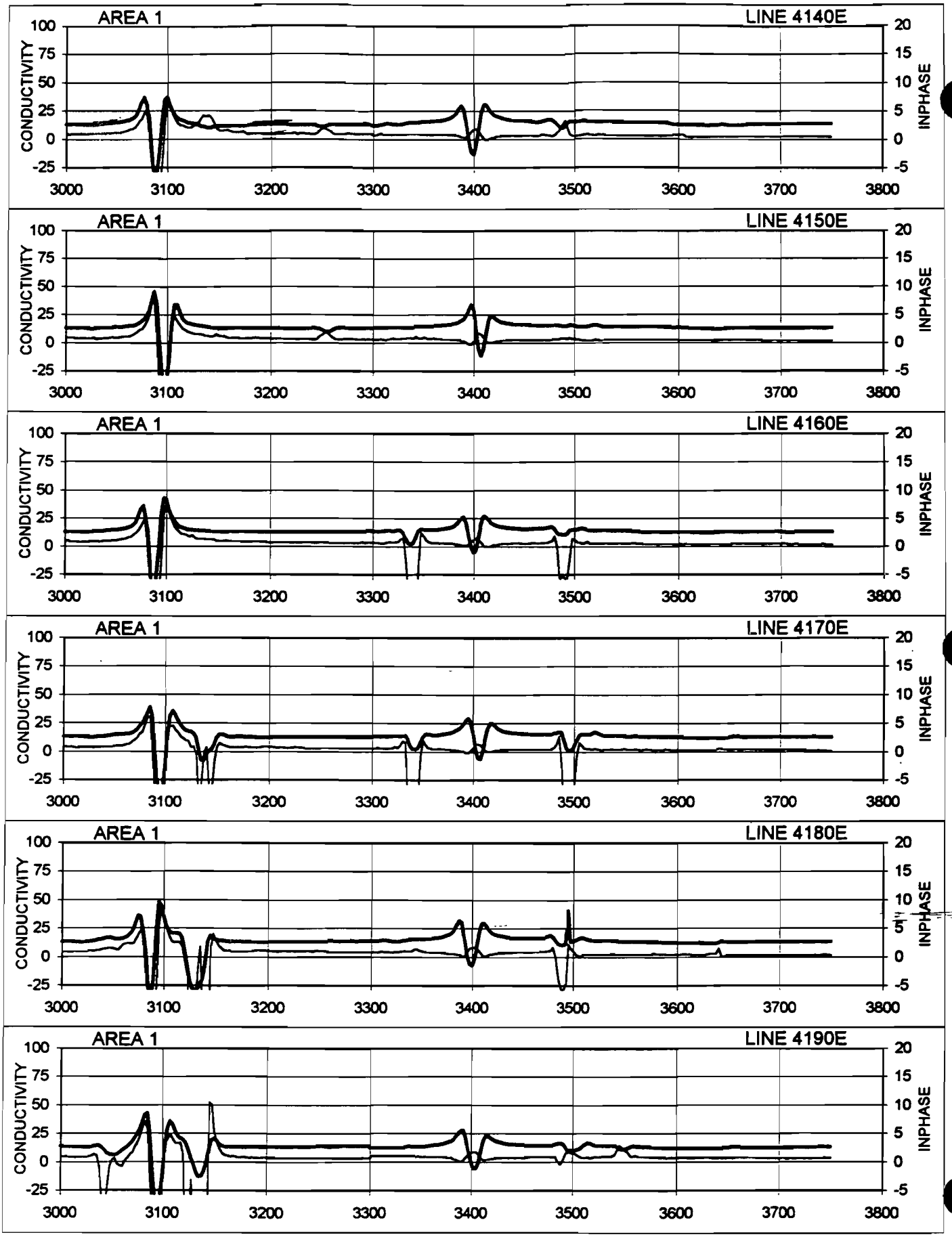
GEOSPHERE MIDWEST

FIGURE B-8



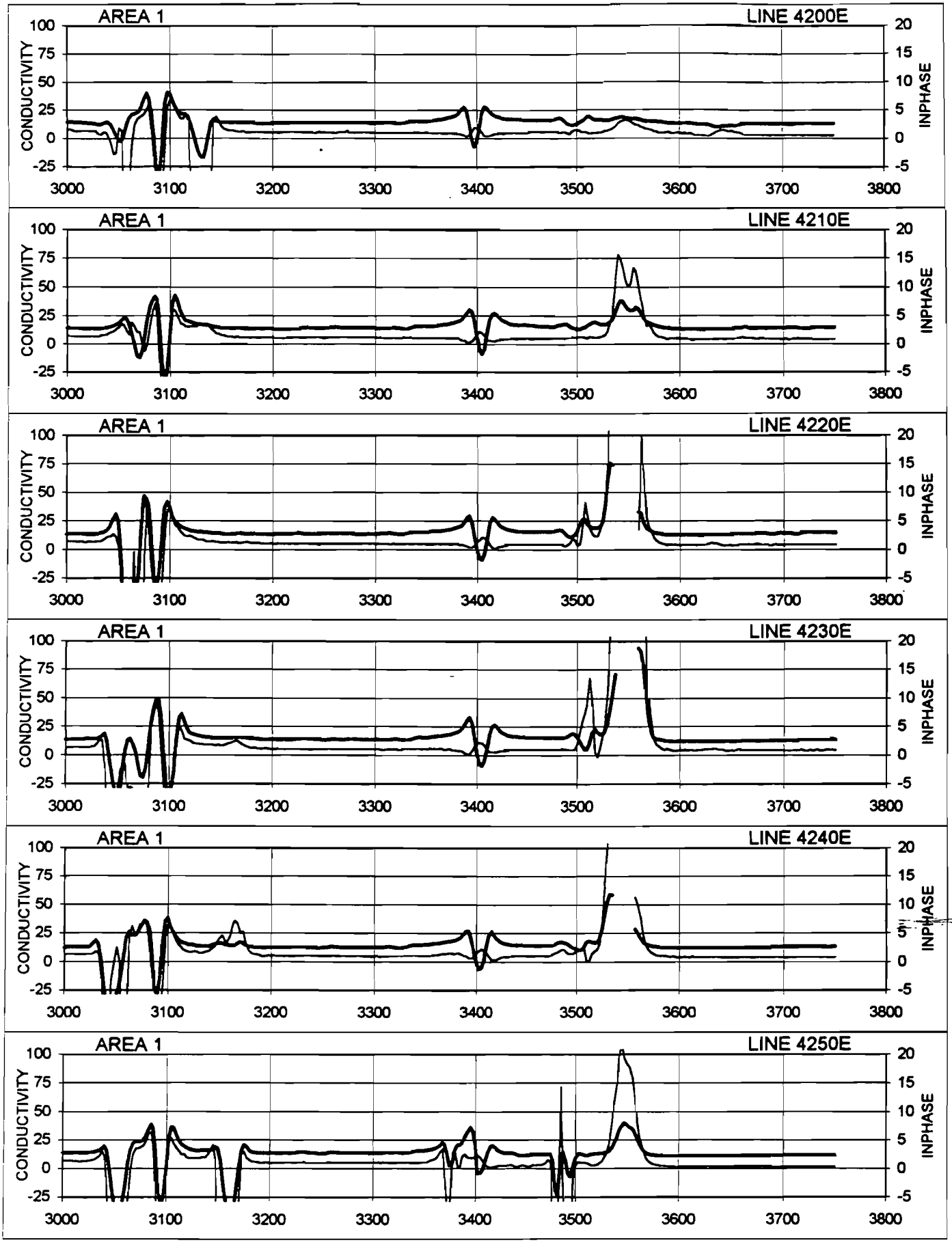
GEOSPHERE MIDWEST

FIGURE B-9



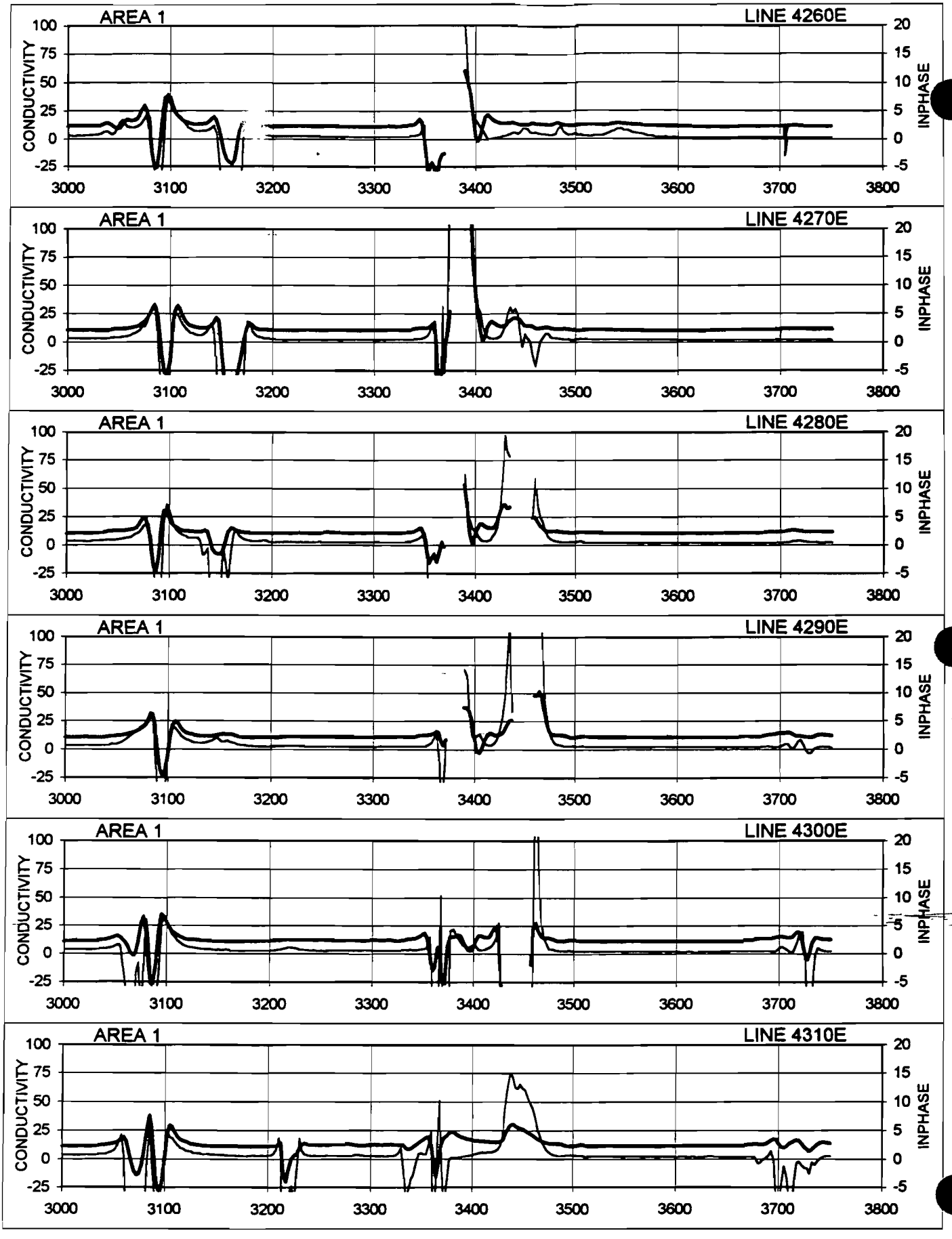
GEOSPHERE MIDWEST

FIGURE B-10



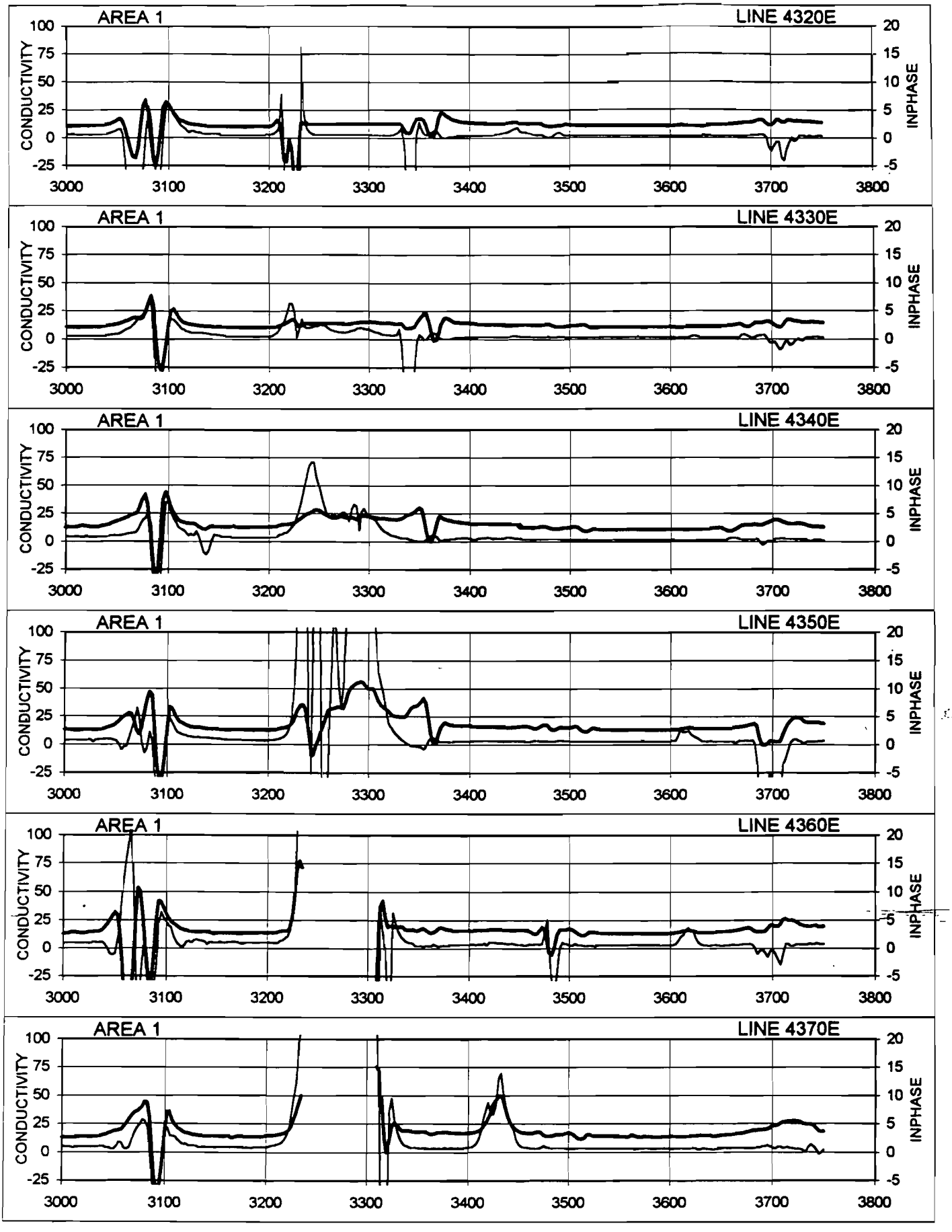
GEOSPHERE MIDWEST

FIGURE B-11



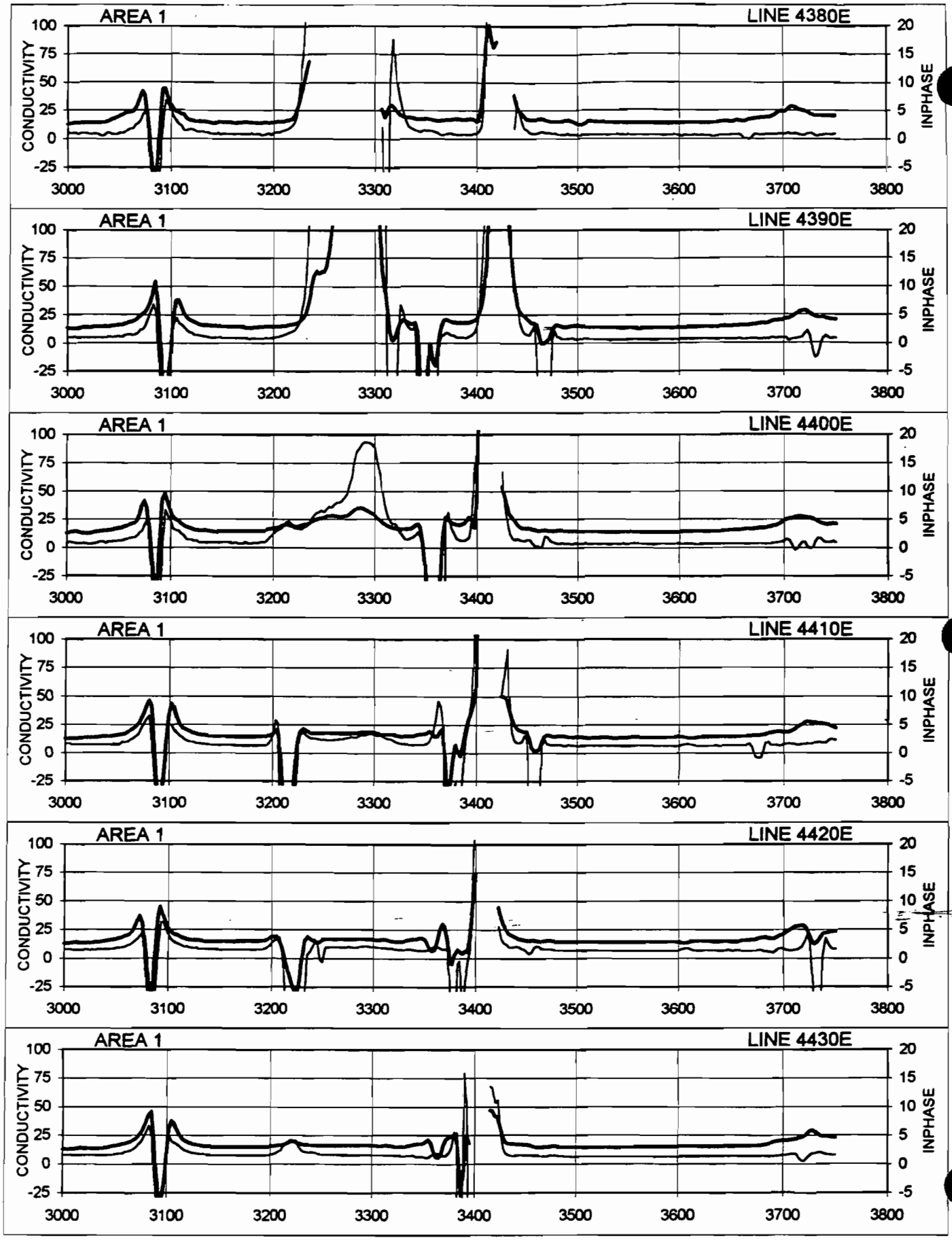
GEOSPHERE MIDWEST

FIGURE B-12



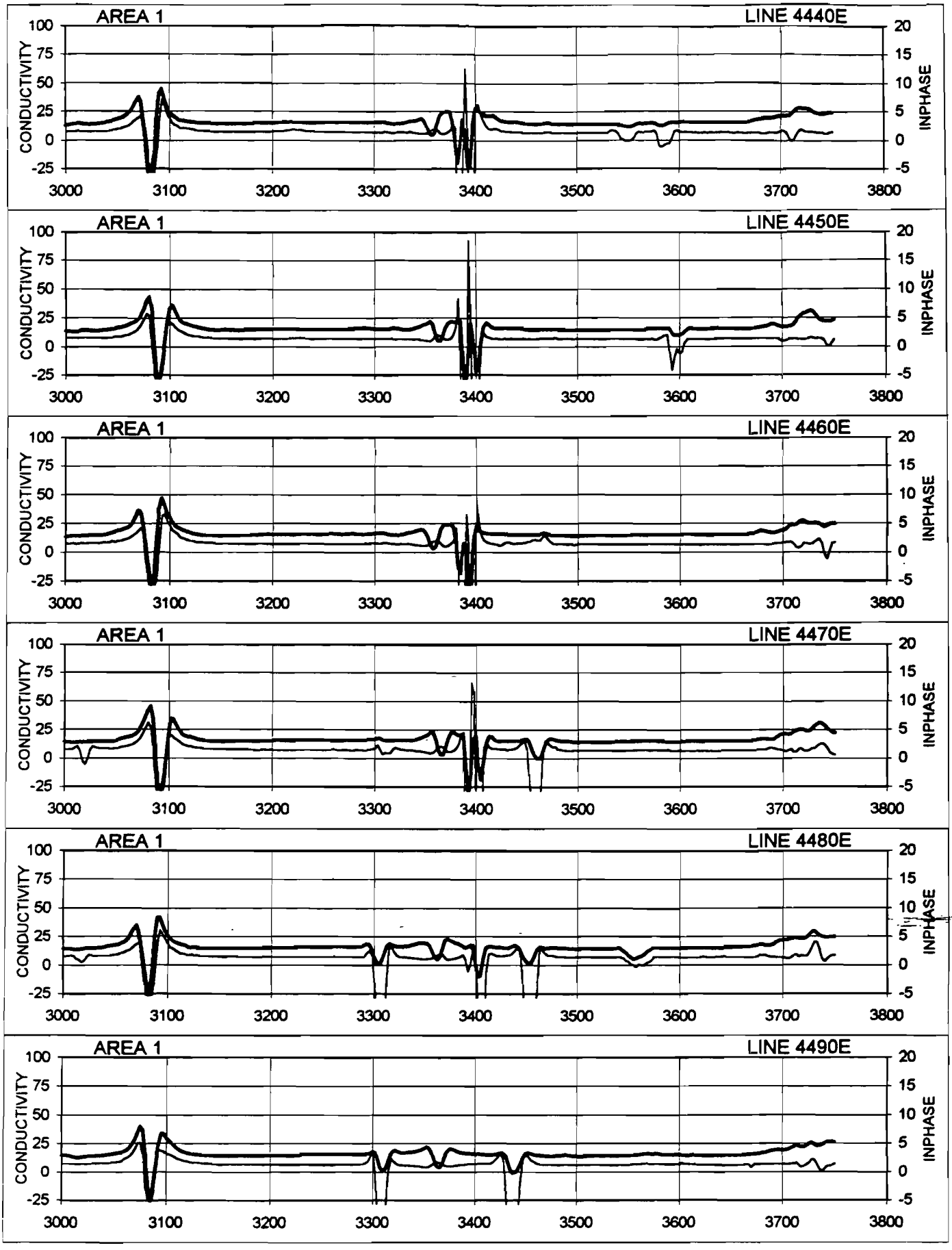
GEOSPHERE MIDWEST

FIGURE B-13



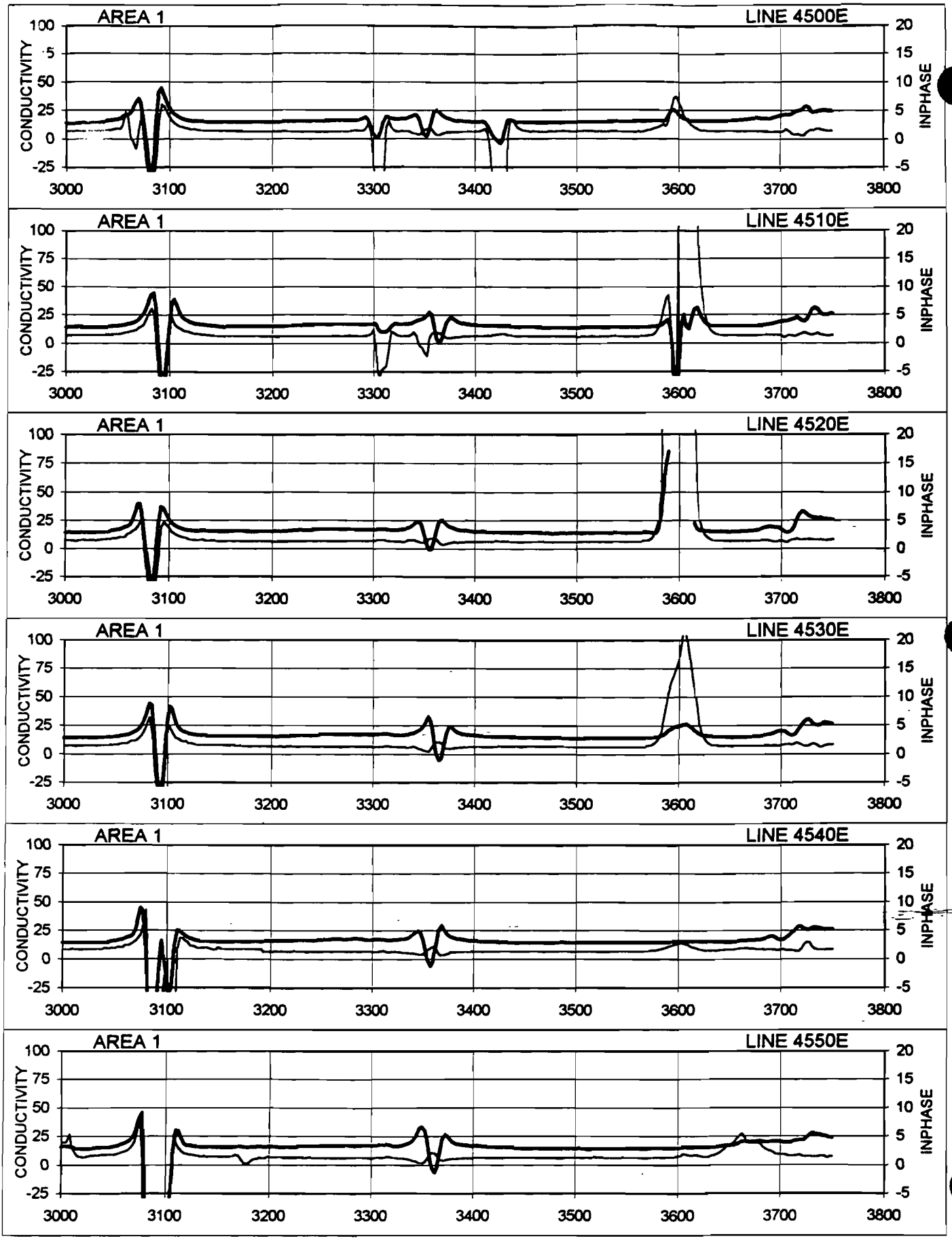
GEOSPHERE MIDWEST

FIGURE B-14



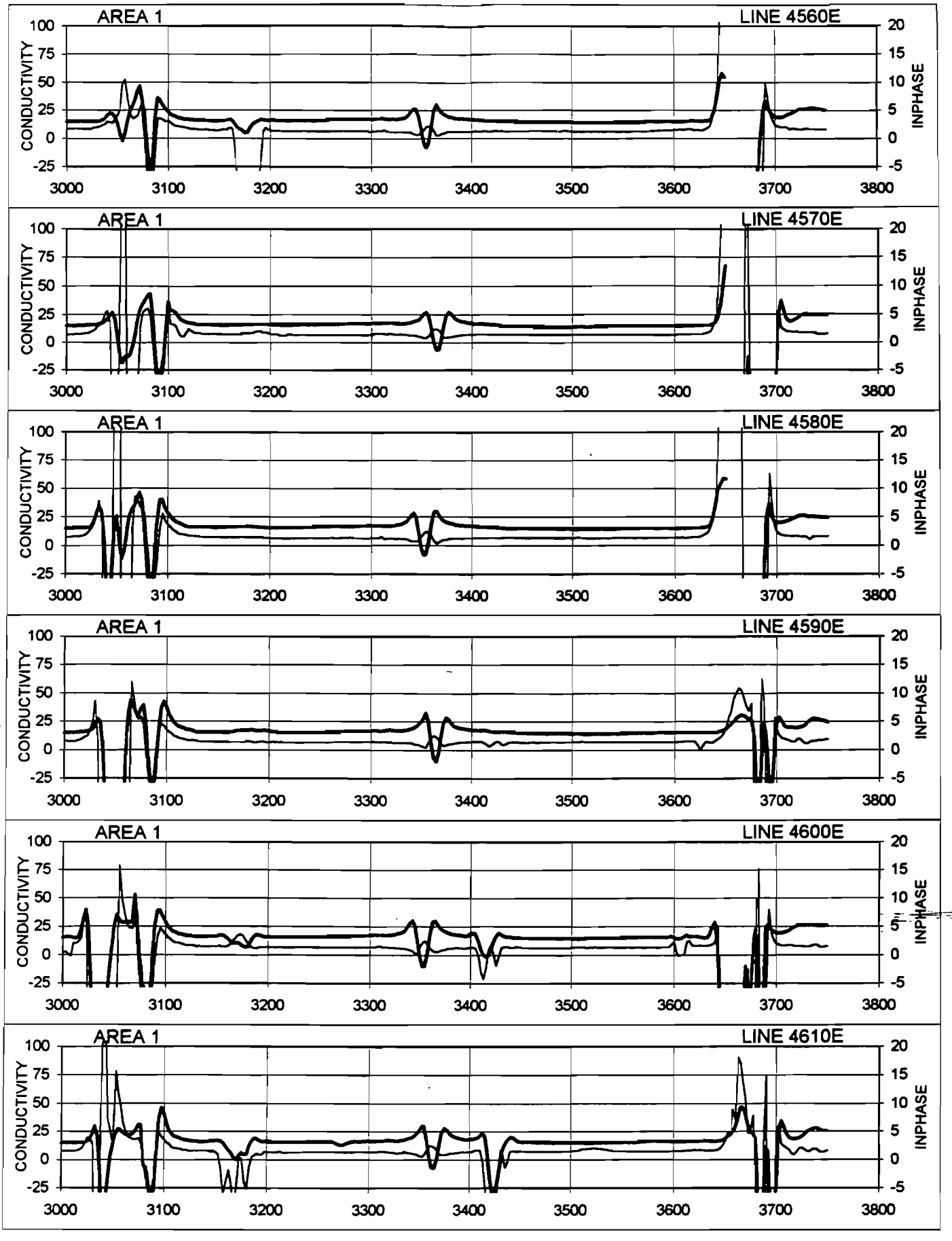
GEOSPHERE MIDWEST

FIGURE B-15



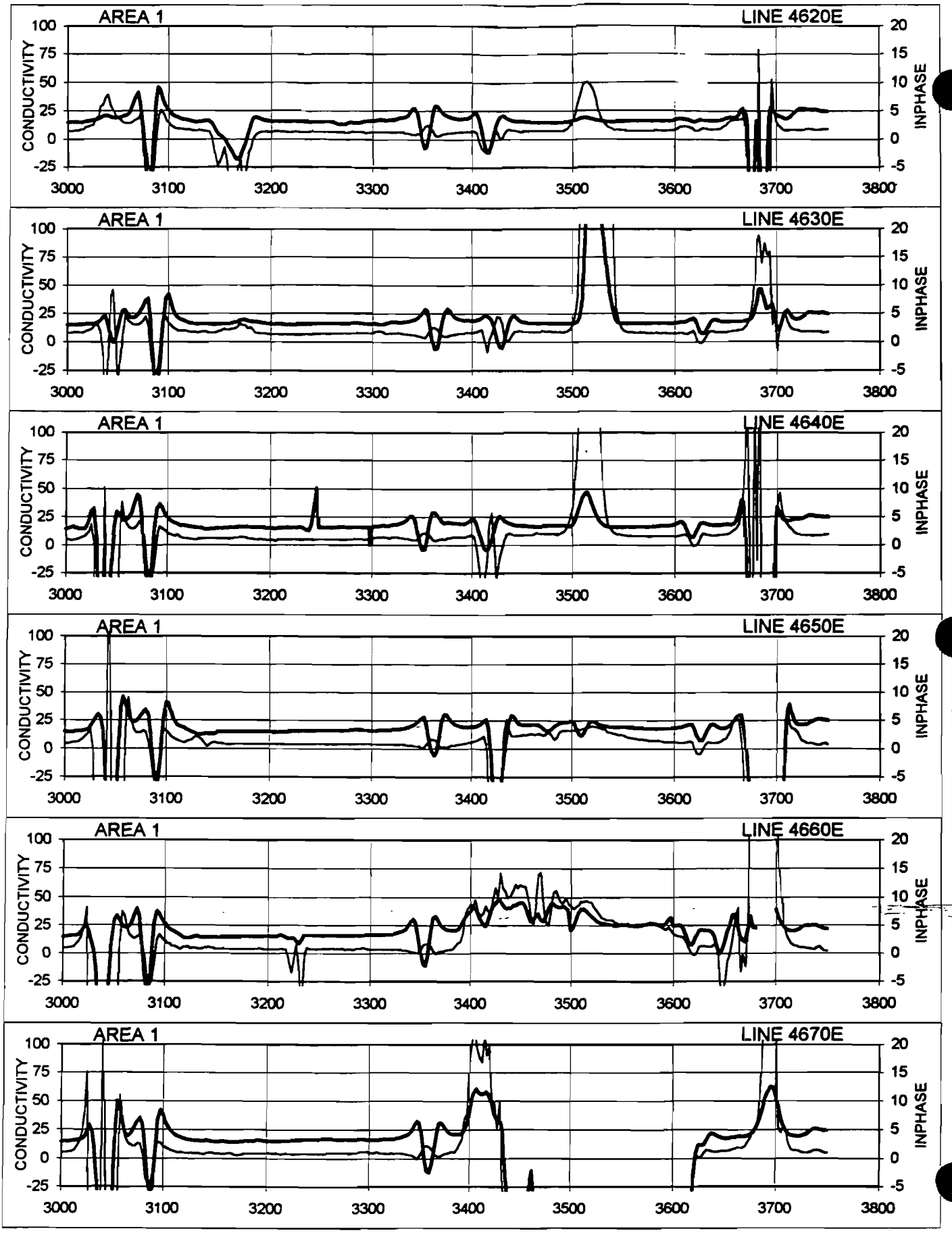
GEOSPHERE MIDWEST

FIGURE B-16



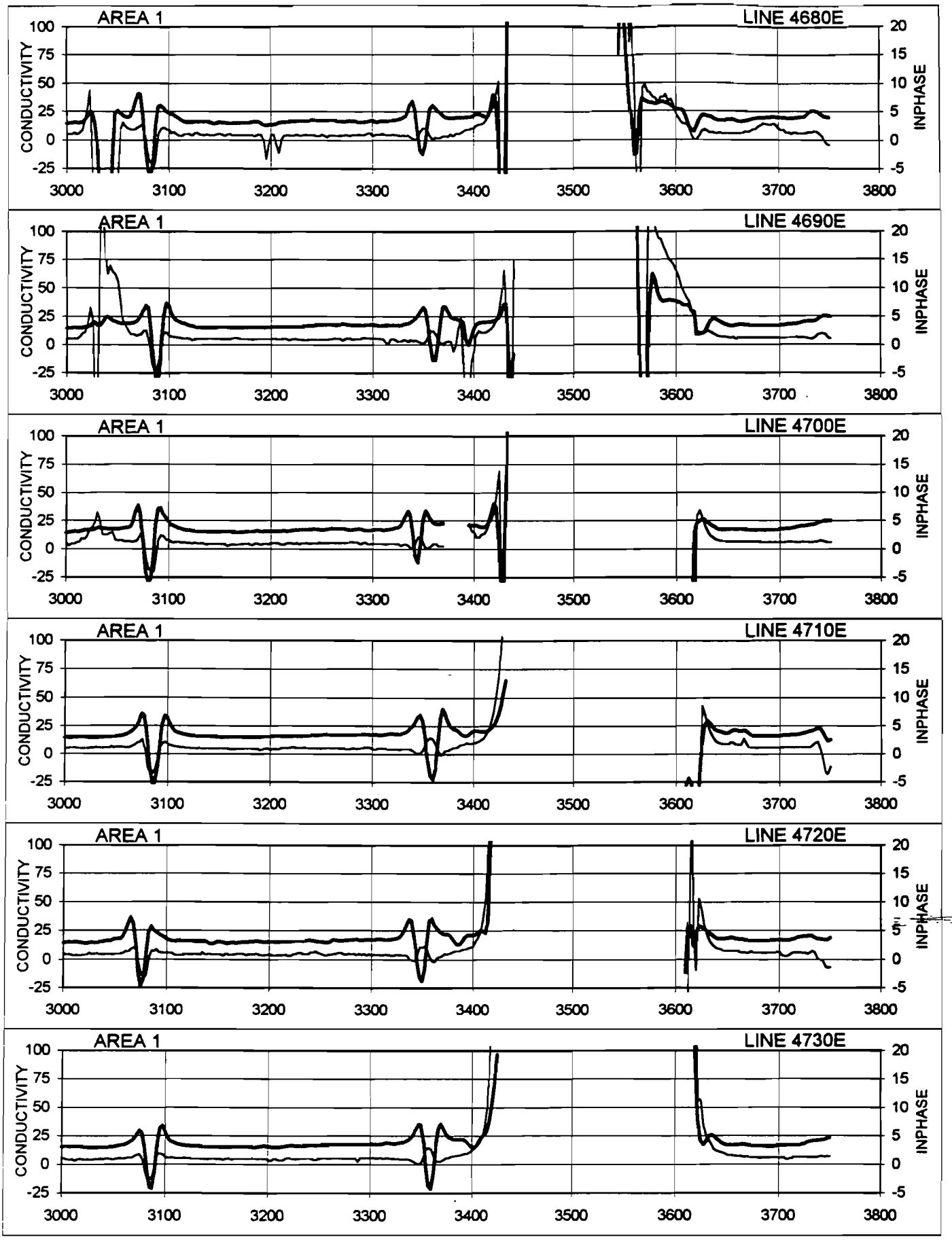
GEOSPHERE MIDWEST

FIGURE B-17



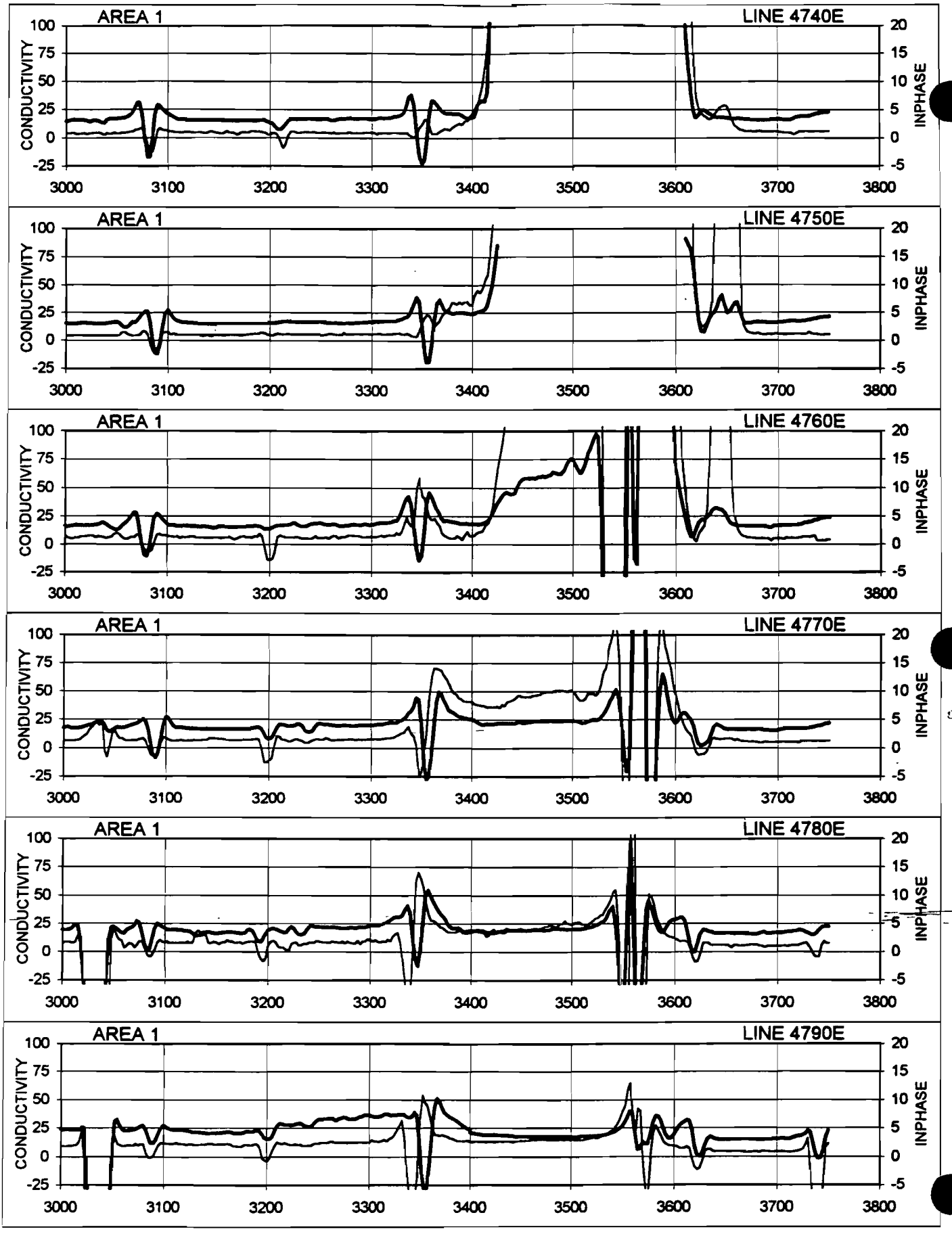
GEOSPHERE MIDWEST

FIGURE B-18



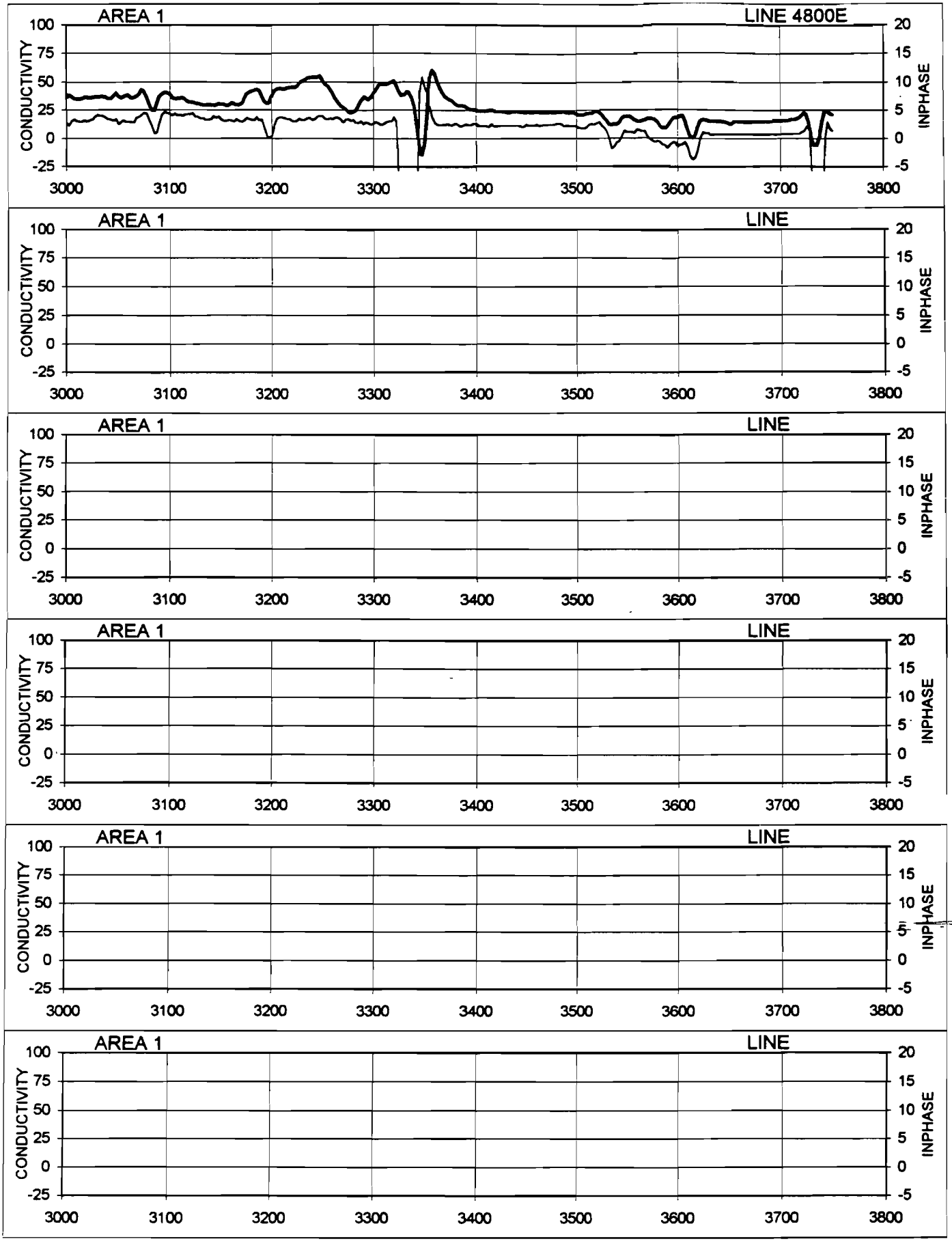
GEOSPHERE MIDWEST

FIGURE B-19



GEOSPHERE MIDWEST

FIGURE B-20



GEOSPHERE MIDWEST

FIGURE B-21

APPENDIX C

SITE 1: EM34 PROFILE DATA

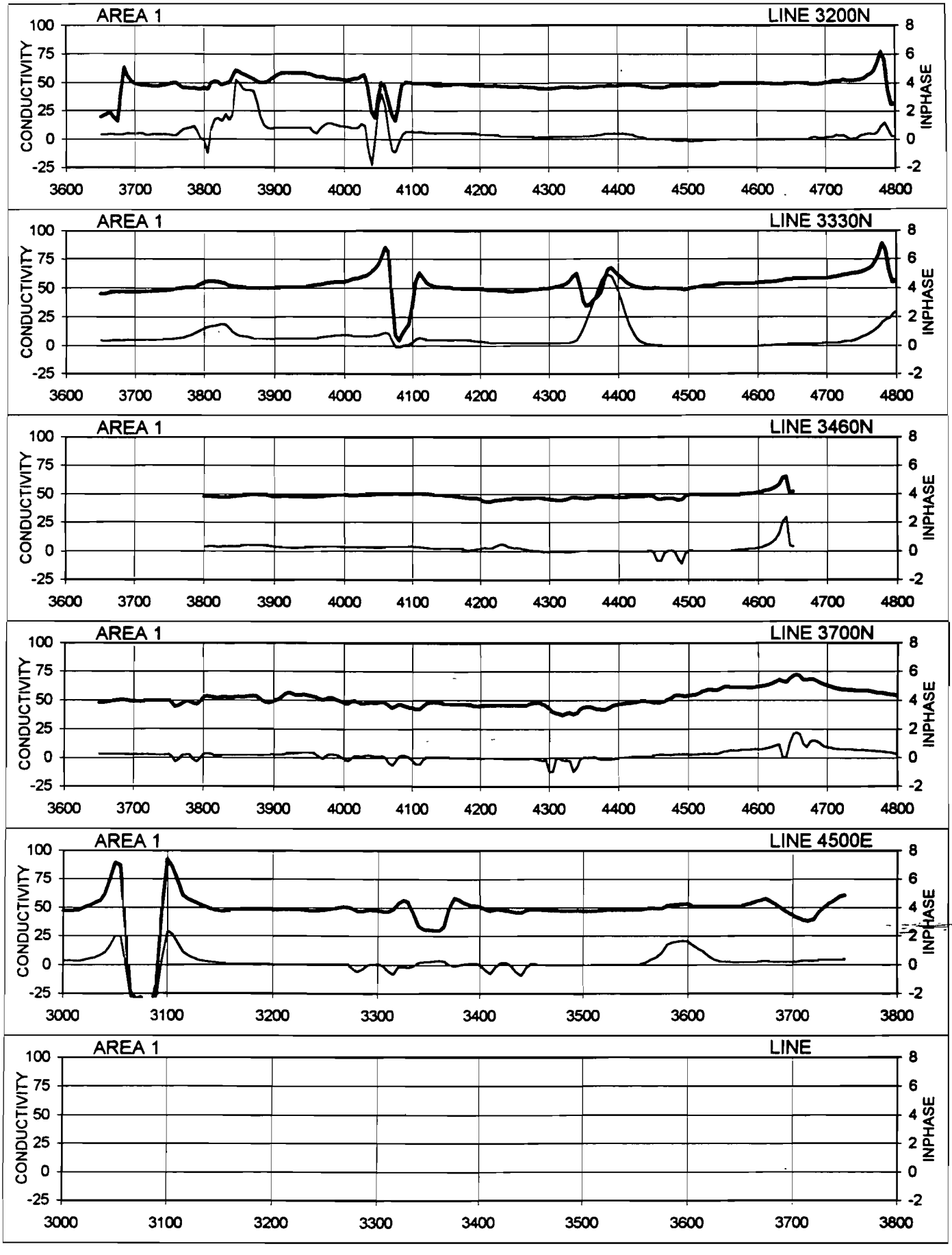
This appendix is a compilation of all EM34 profile data obtained at Site 1. Locations of these EM lines are given in Figure 3.2. The following profiles include line number (northing/easting coordinate), conductivity and inphase (vertical) scales and station location labels (easting/northing coordinates). Conductivity values are given in millimhos/meter (mmhos/m), inphase values are given in parts per thousand (ppt) and location coordinates are in feet.

C1. EM34 SURVEY: E-W PROFILES FROM SITE 1

Figure C-1

C2. EM34 SURVEY: N-S PROFILE FROM SITE 1

Figure C-1



GEOSPHERE MIDWEST

FIGURE C-1

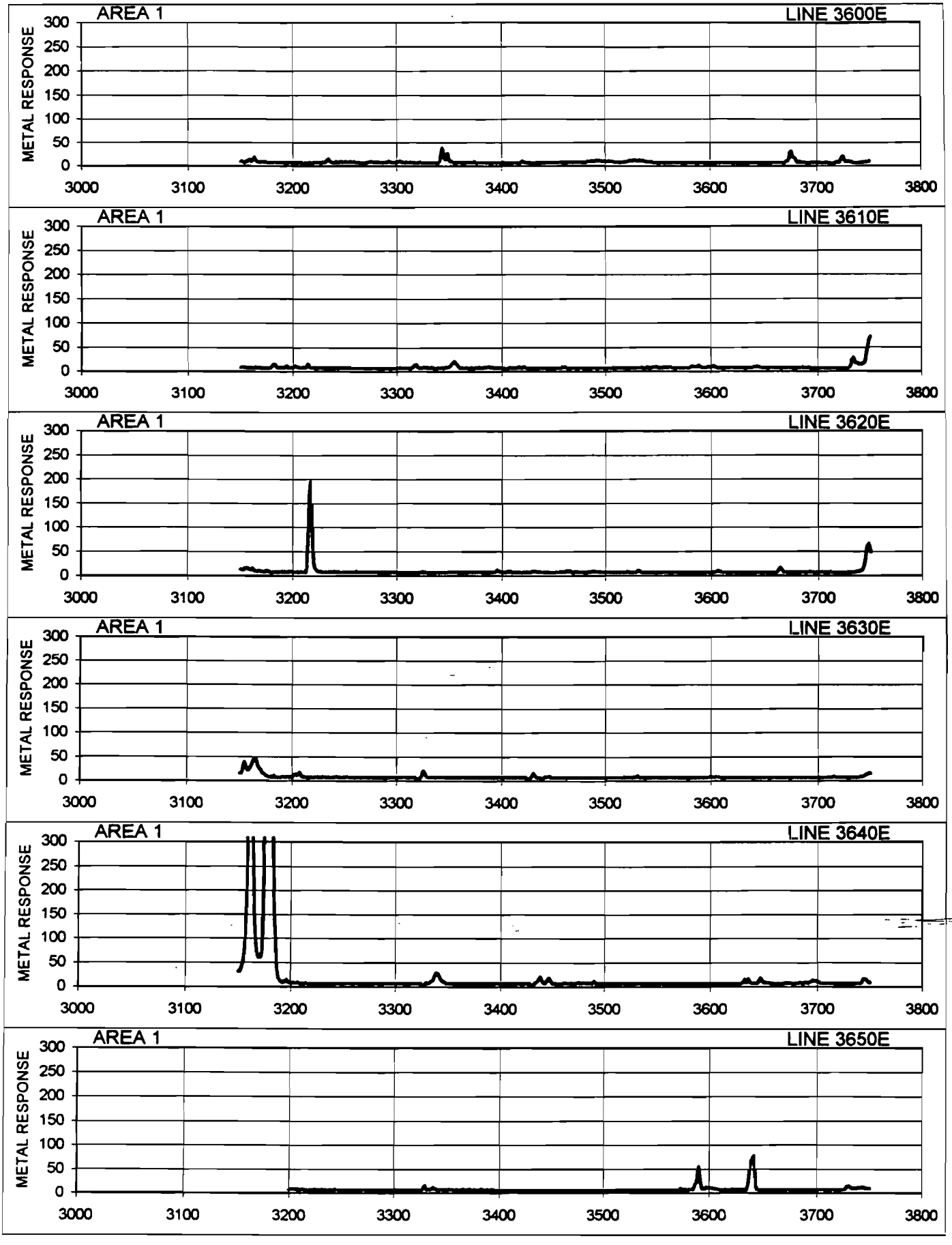
APPENDIX D

SITE 1: EM61 PROFILE DATA

This appendix is a compilation of all EM61 profile data obtained at Site 1. Locations of these EM61 lines are given in Figure 3.3. The following profiles include line number (easting coordinate), metal response (vertical) scales and station location labels (northing coordinates). Metal response values are given in millivolts; location coordinates are in feet.

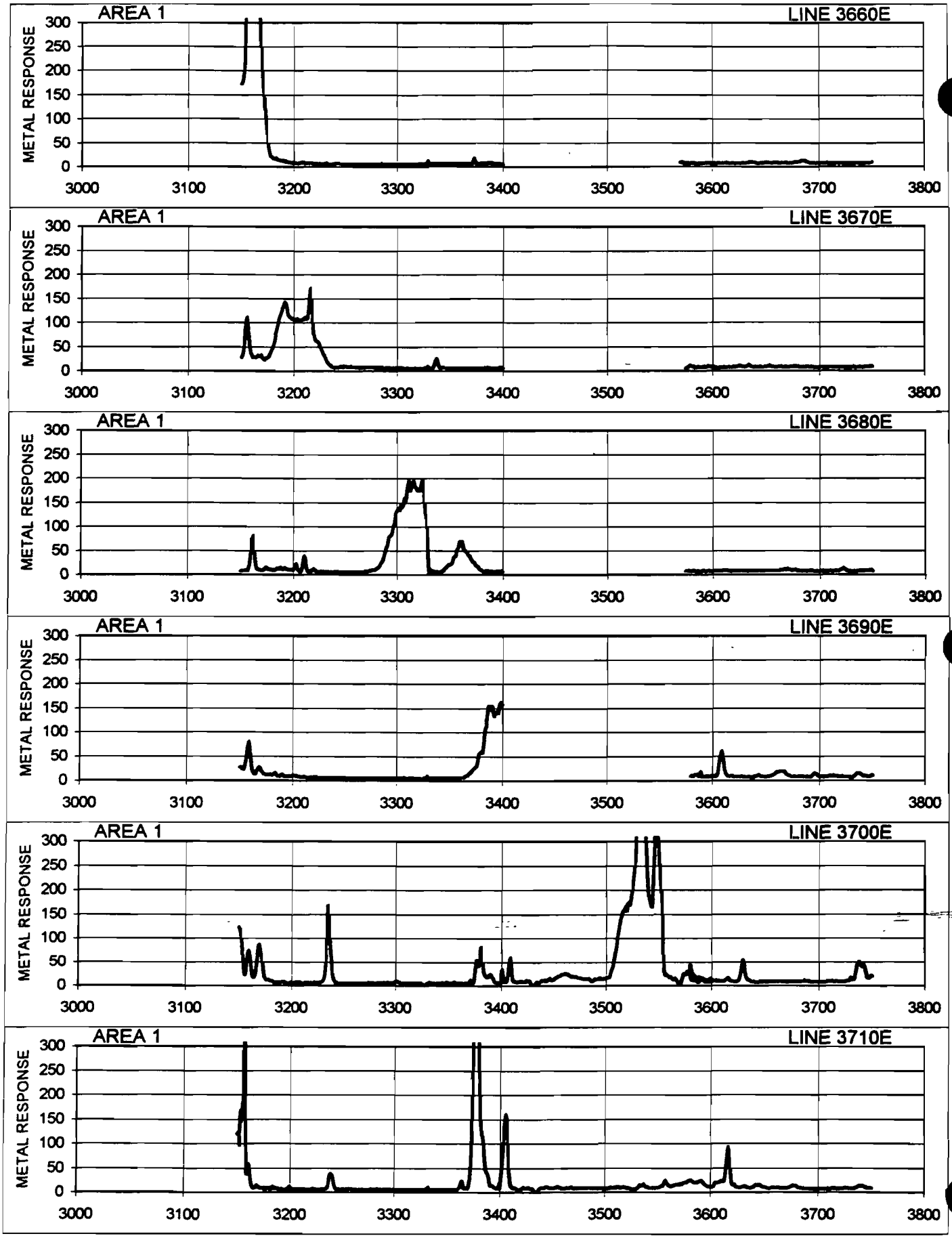
D1. EM61 SURVEY: N-S PROFILES FROM SITE 1

Figures D-1 to D-21.



GEOSPHERE MIDWEST

FIGURE D-1



GEOSPHERE MIDWEST

FIGURE D-2

APPENDIX H

SITE 5: EM31 PROFILE DATA

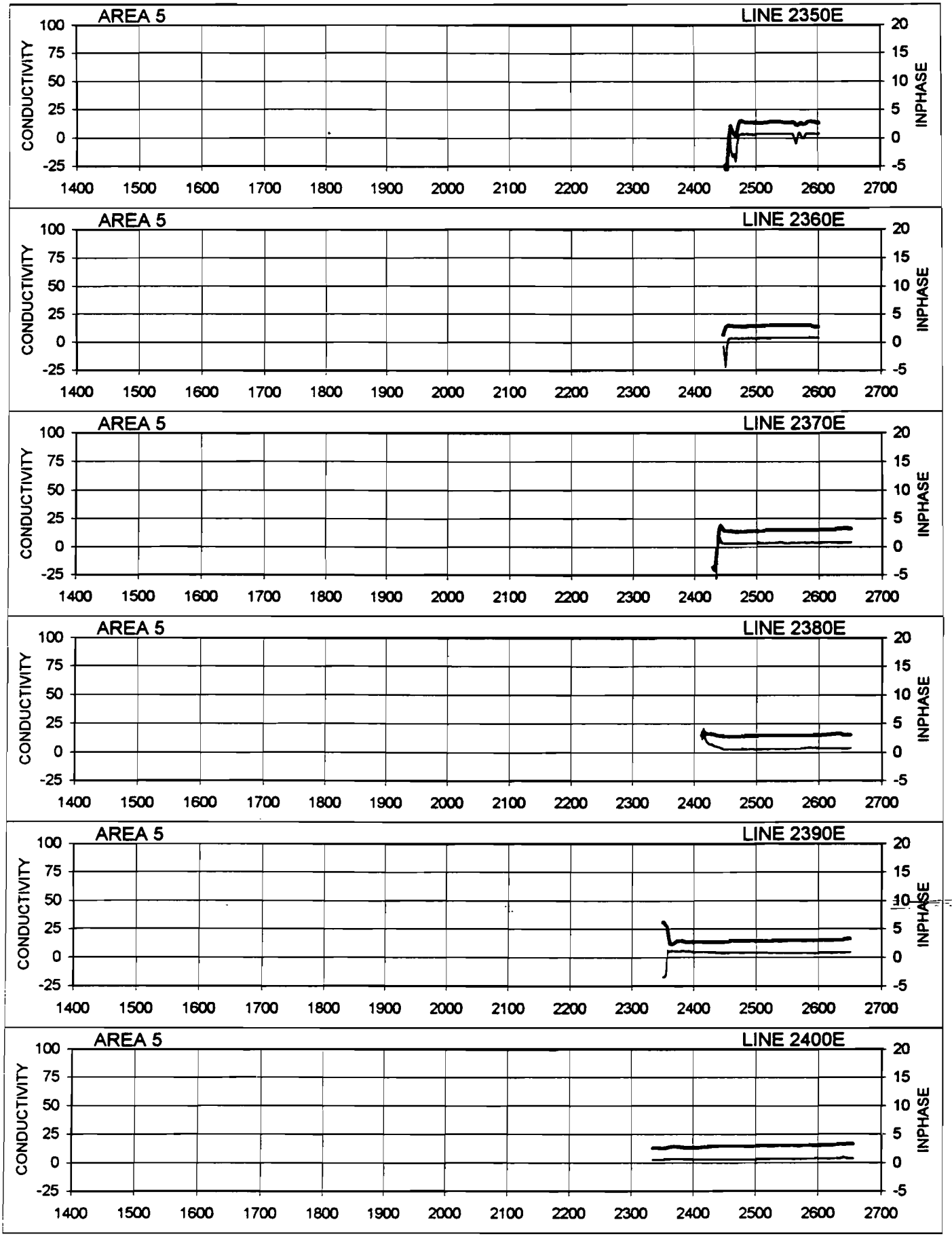
This appendix is a compilation of all EM31 profile data obtained at Site 5. Locations of these EM lines are given in Figure 5.2. The following profiles include line number (easting coordinate), conductivity and inphase (vertical) scales and station location labels (northing coordinates). Conductivity values are given in millimhos/meter (mmhos/m), inphase values are given in parts per thousand (ppt) and location coordinates are in feet.

H1. EM31 SURVEY: N-S PROFILES FROM SITE 5

Figures H-1 to H-16.

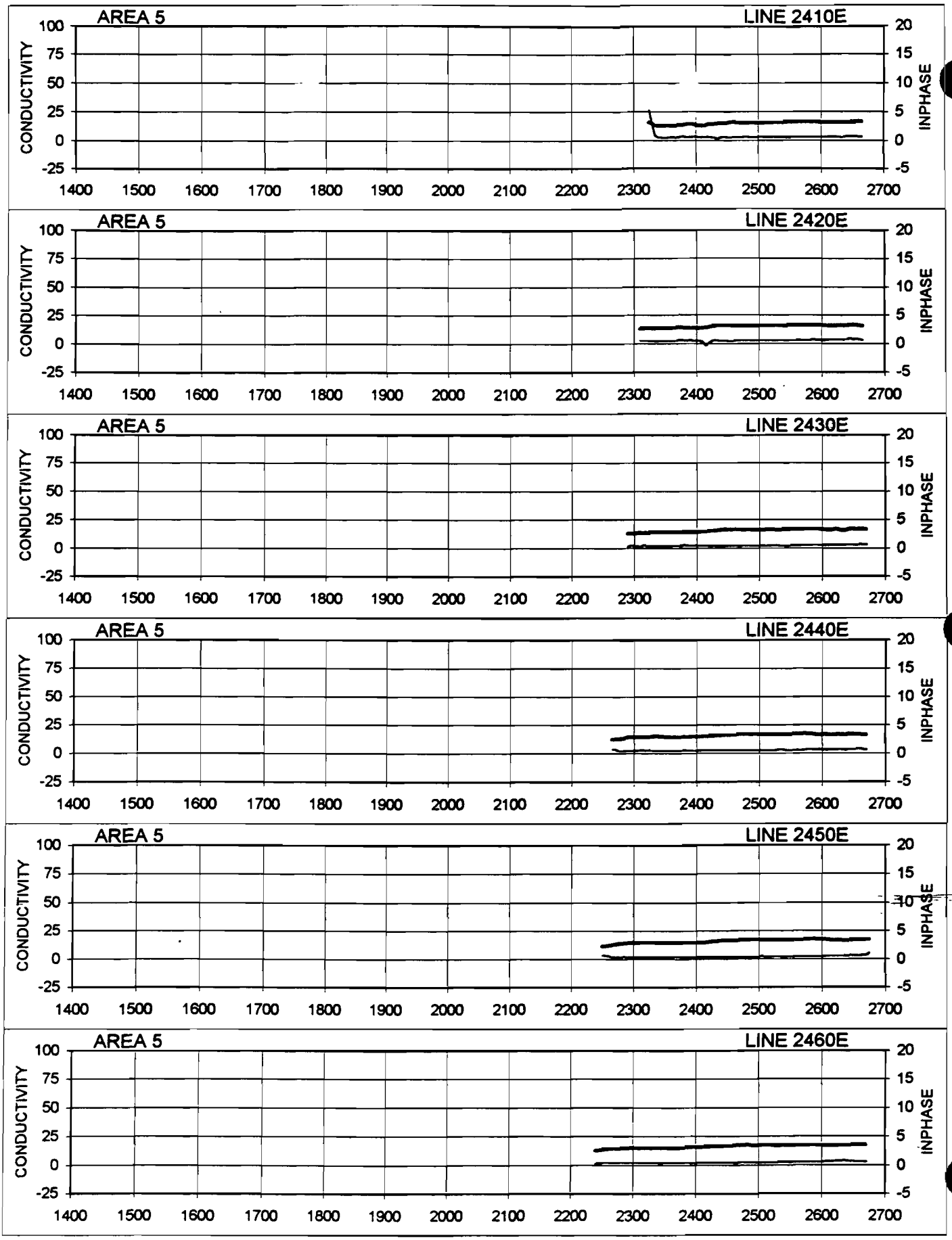
H2. EM31 SURVEY: E-W PROFILES FROM SITE 5

Figure H-17.



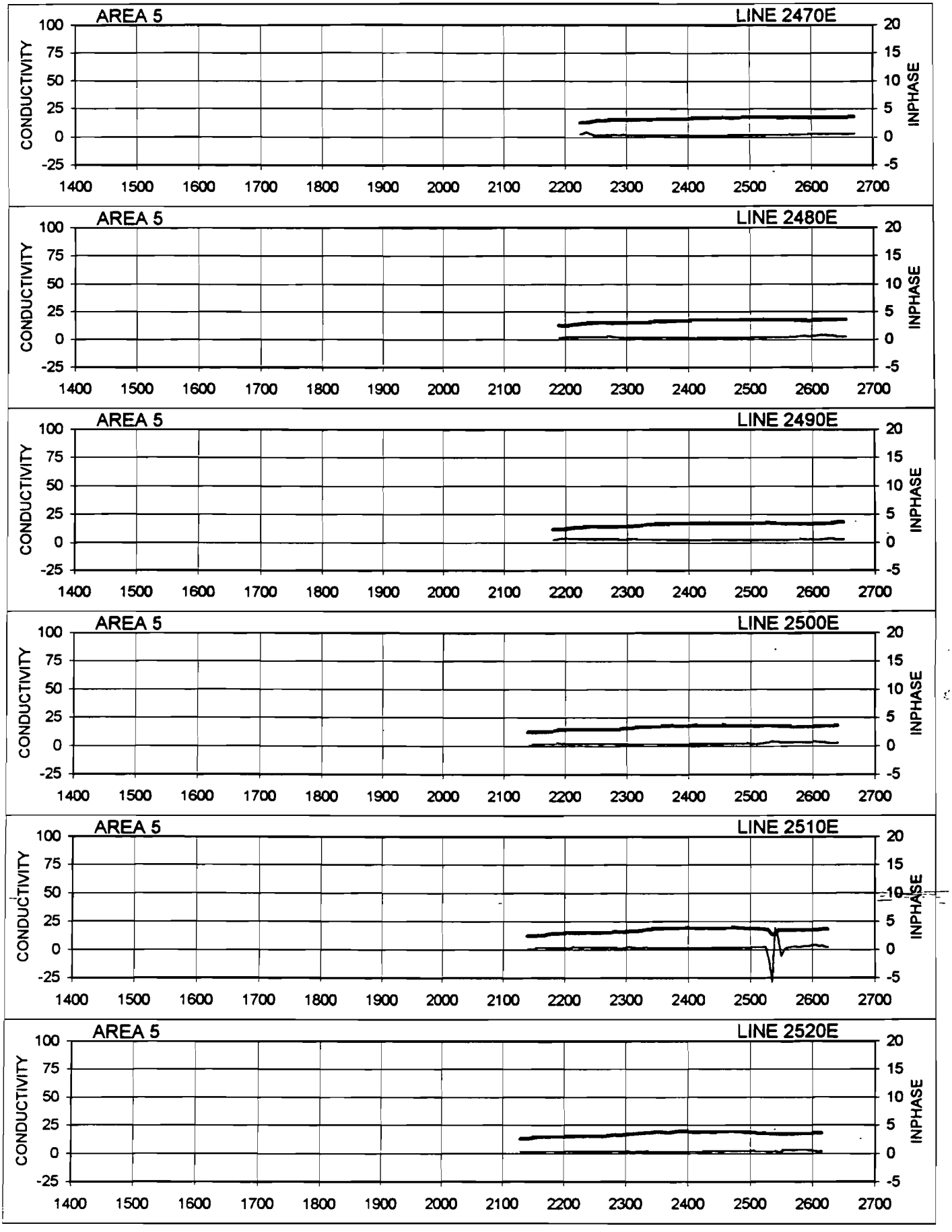
GEOSPHERE MIDWEST

FIGURE H-1



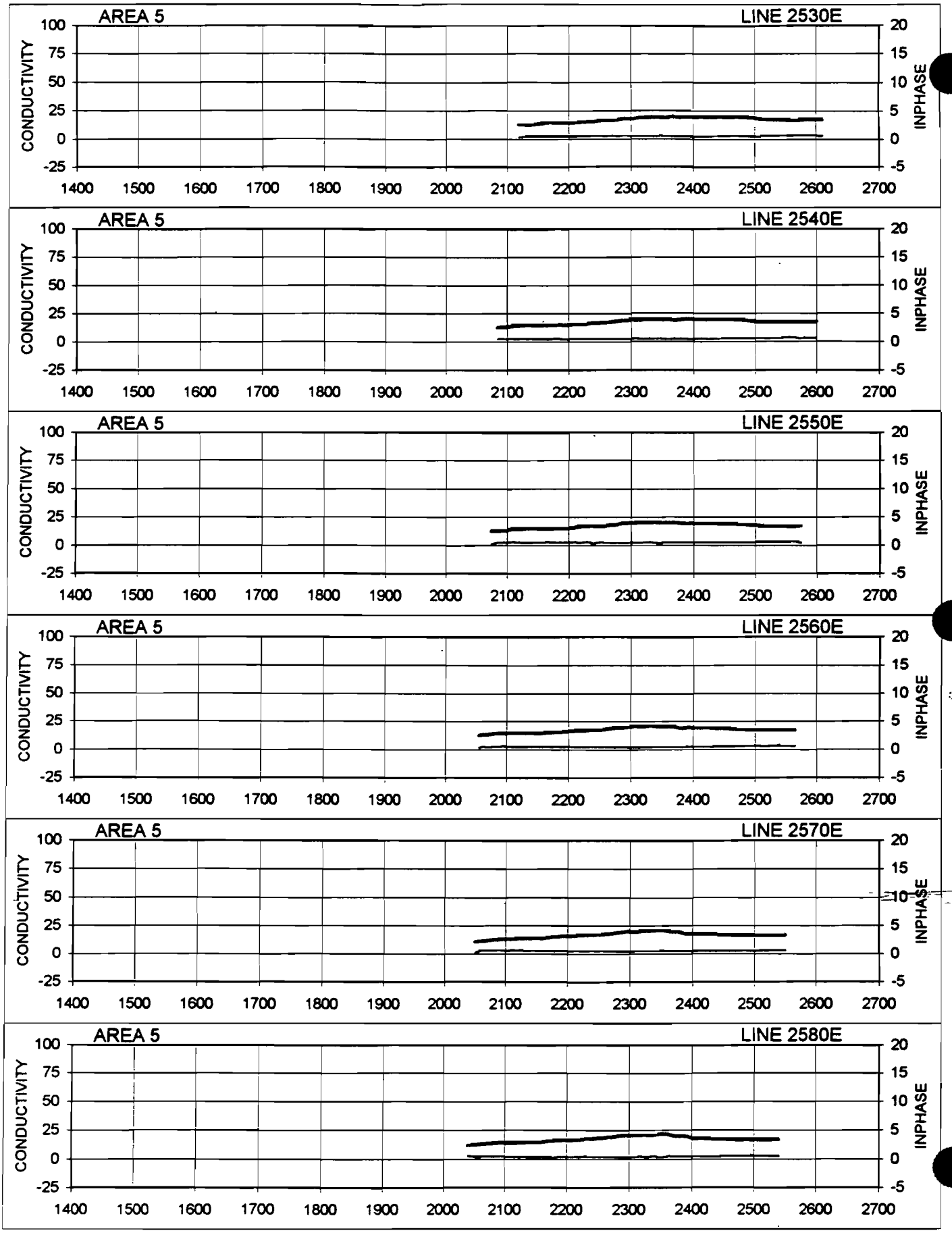
GEOSPHERE MIDWEST

FIGURE H-2



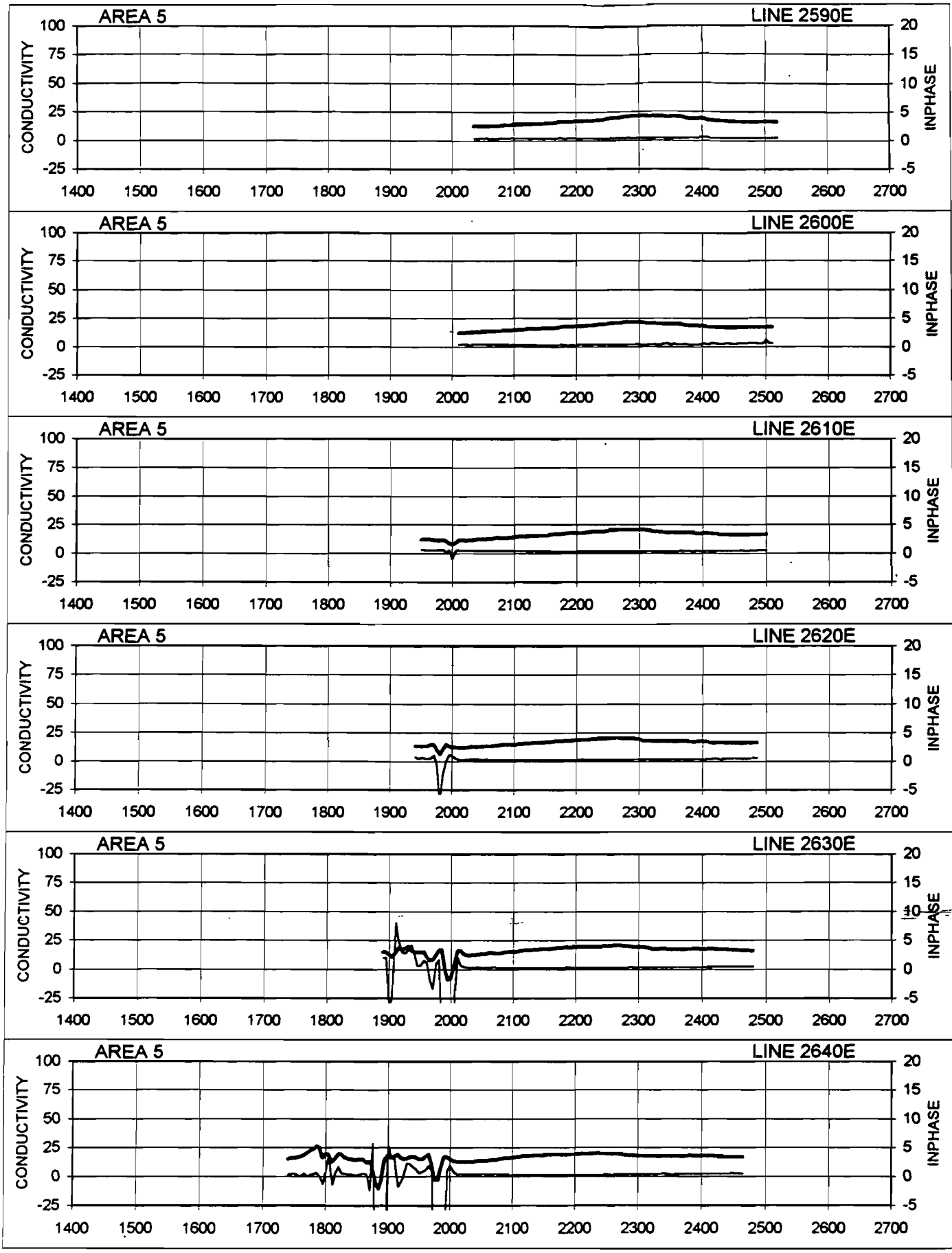
GEOSPHERE MIDWEST

FIGURE H-3



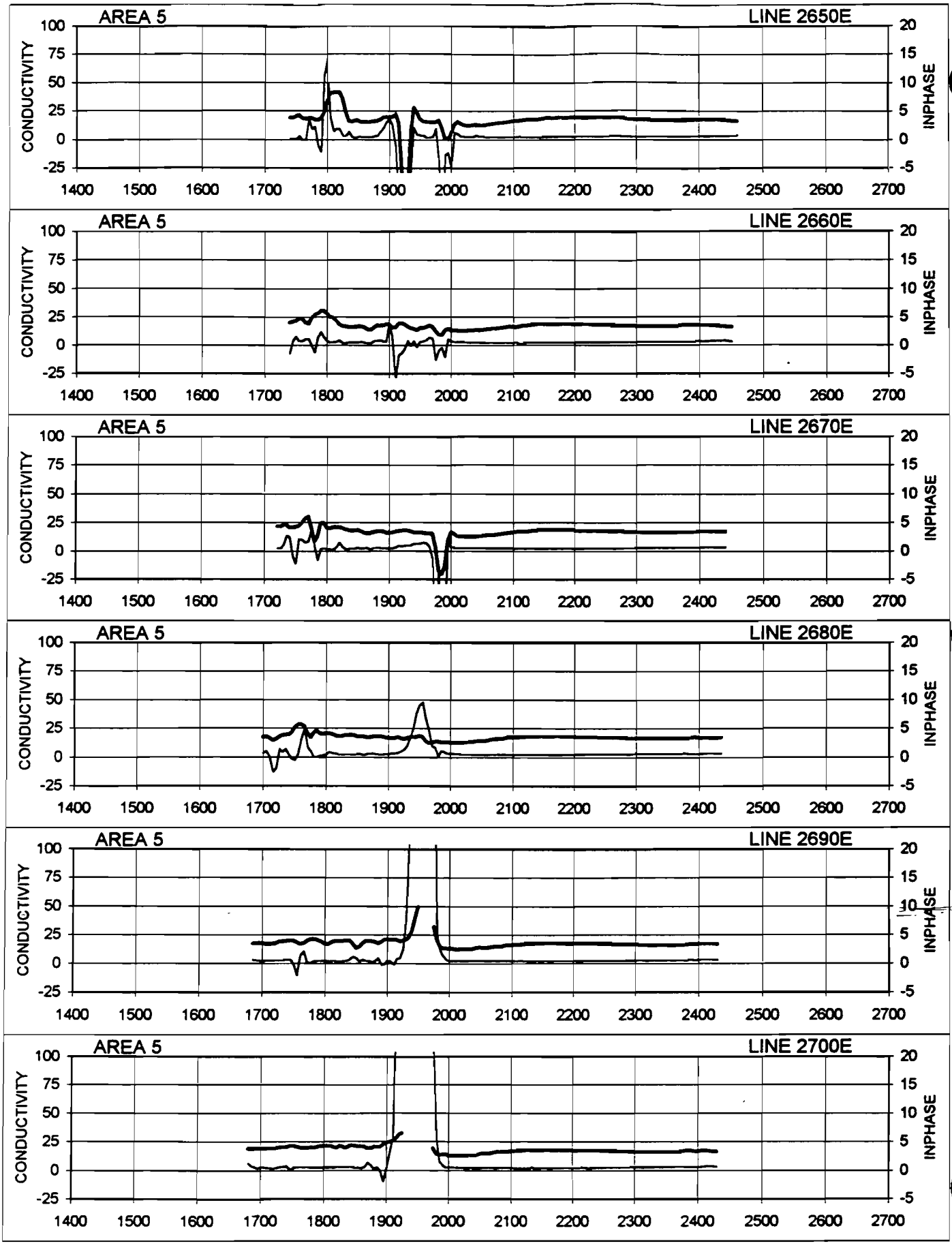
GEOSPHERE MIDWEST

FIGURE H-4



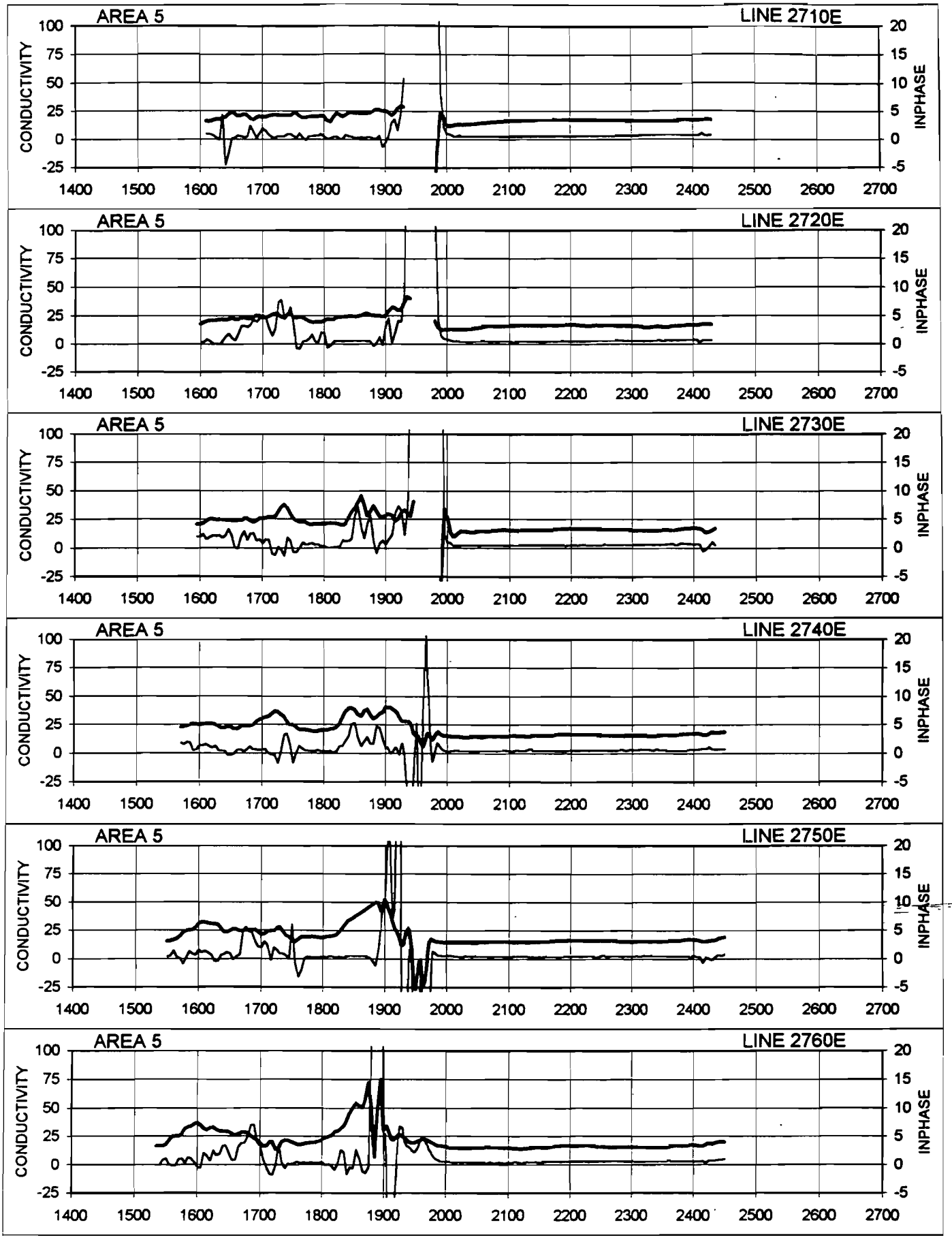
GEOSPHERE MIDWEST

FIGURE H-5



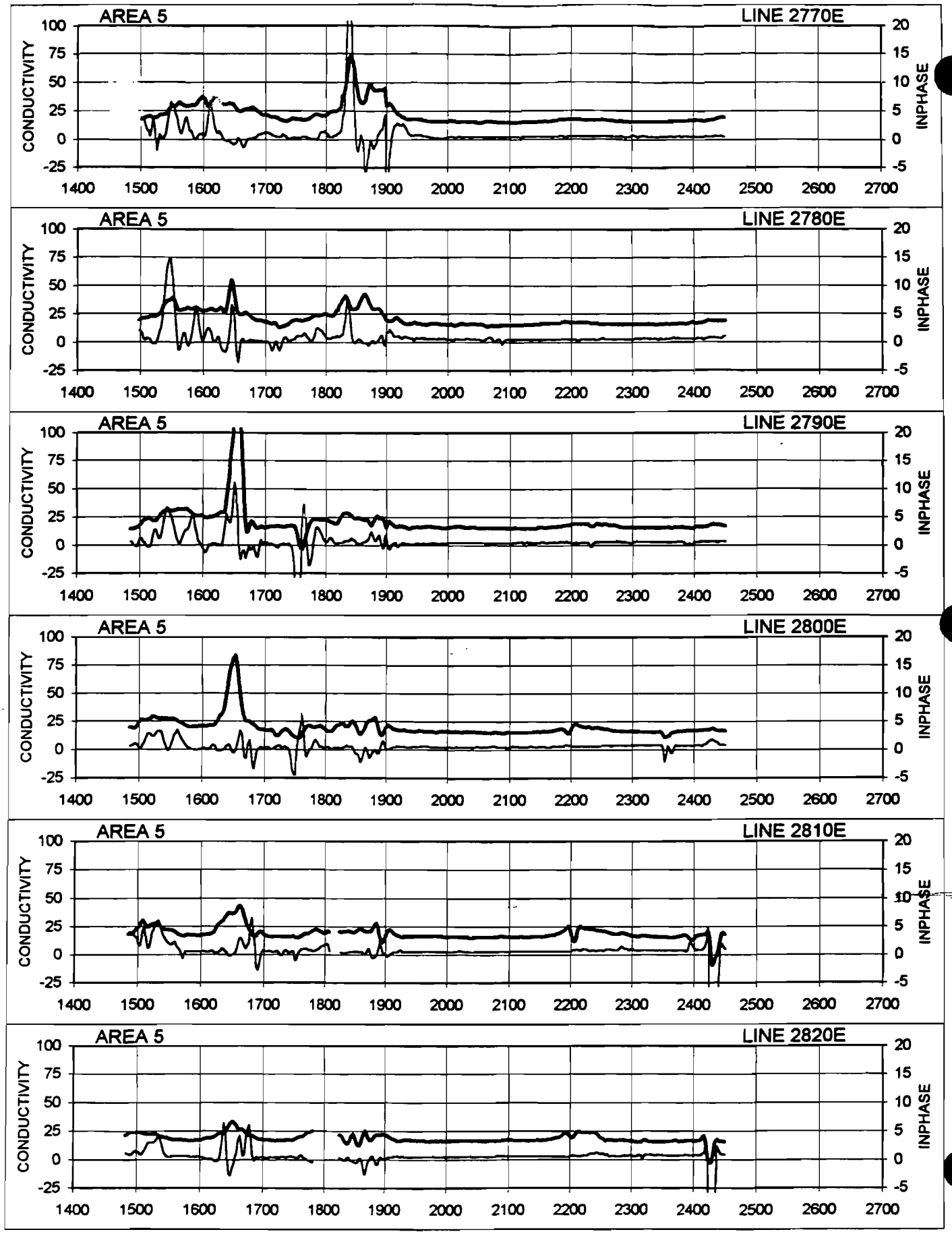
GEOSPHERE MIDWEST

FIGURE H-6



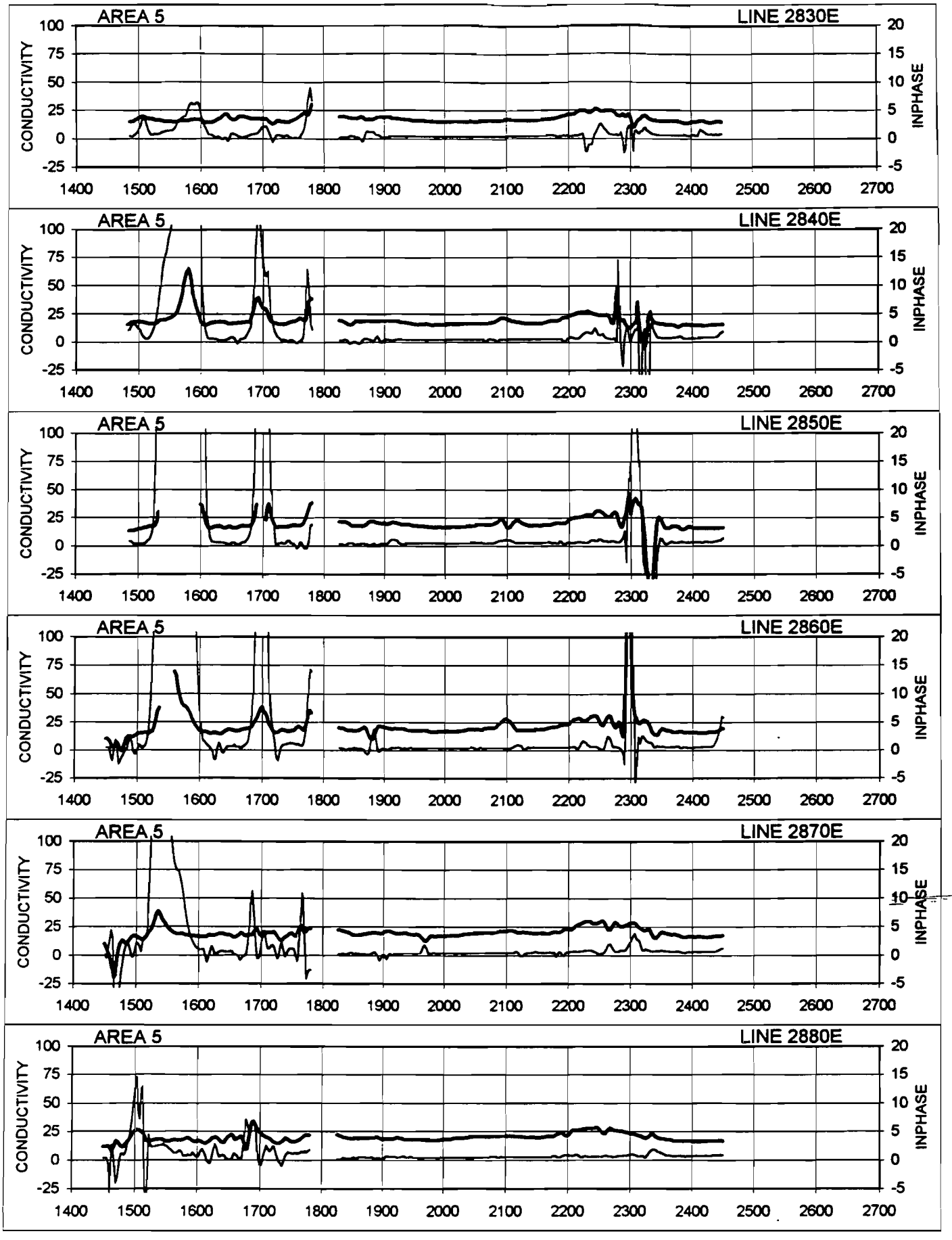
GEOSPHERE MIDWEST

FIGURE H-7



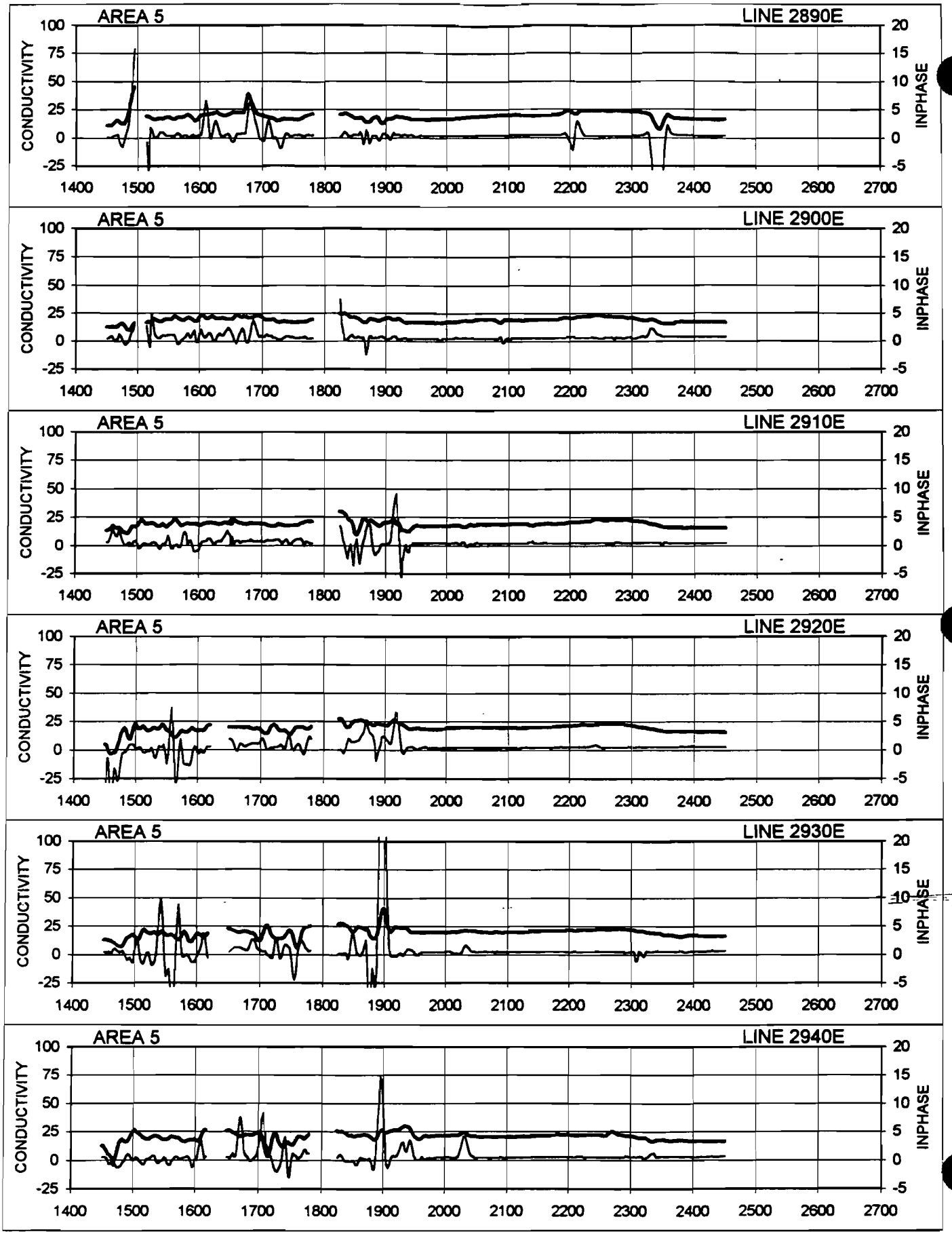
GEOSPHERE MIDWEST

FIGURE H-8



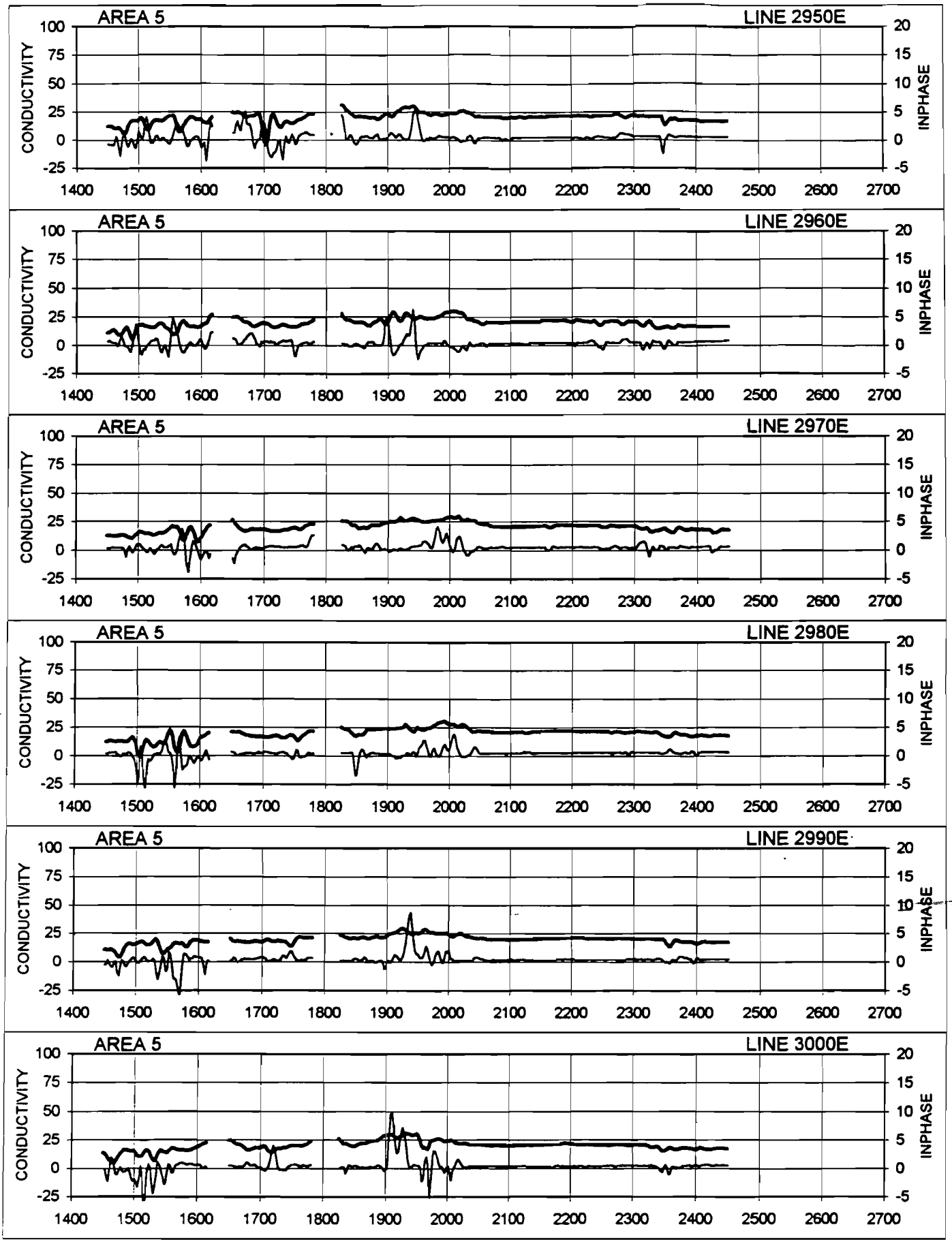
GEOSPHERE MIDWEST

FIGURE H-9



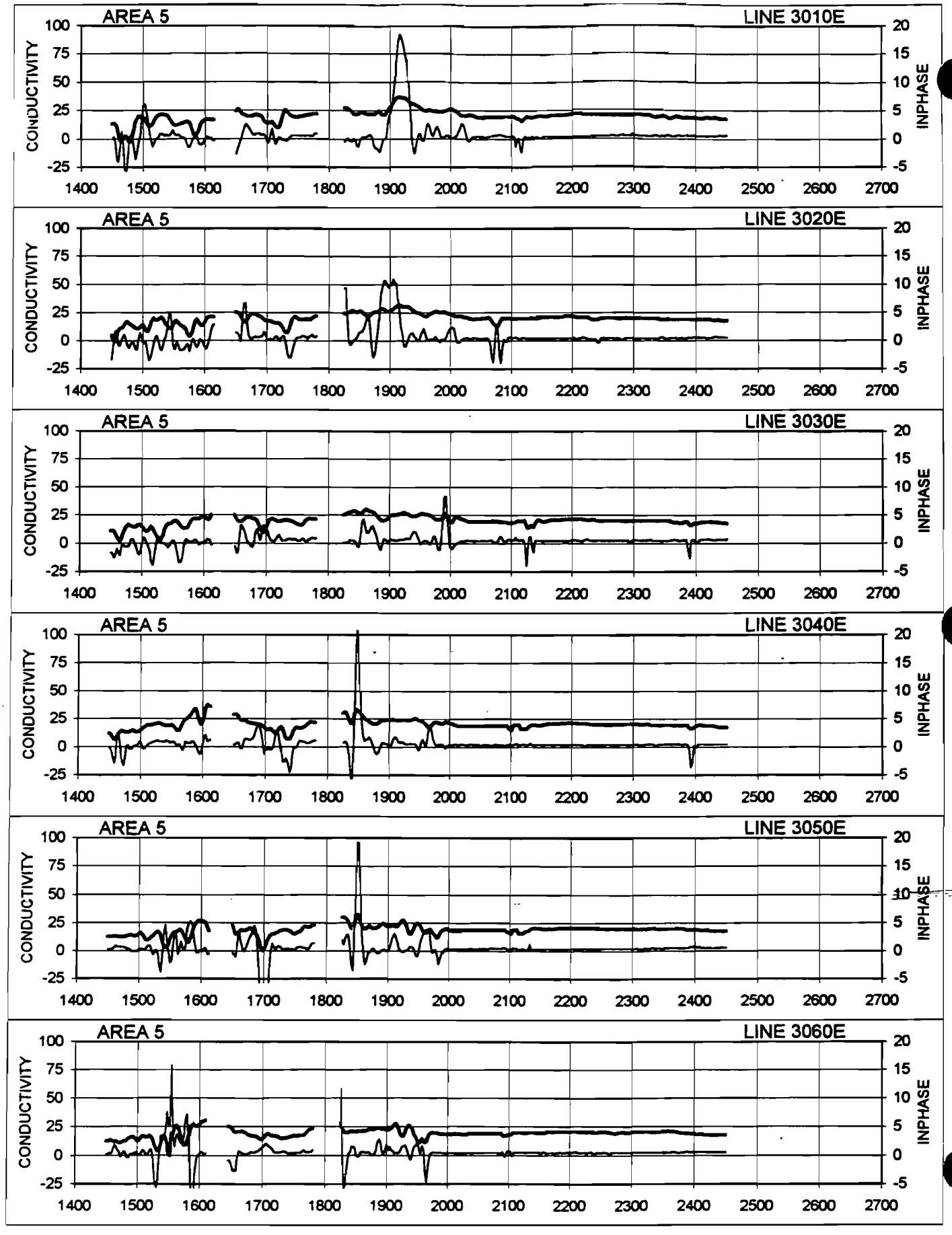
GEOSPHERE MIDWEST

FIGURE H-10



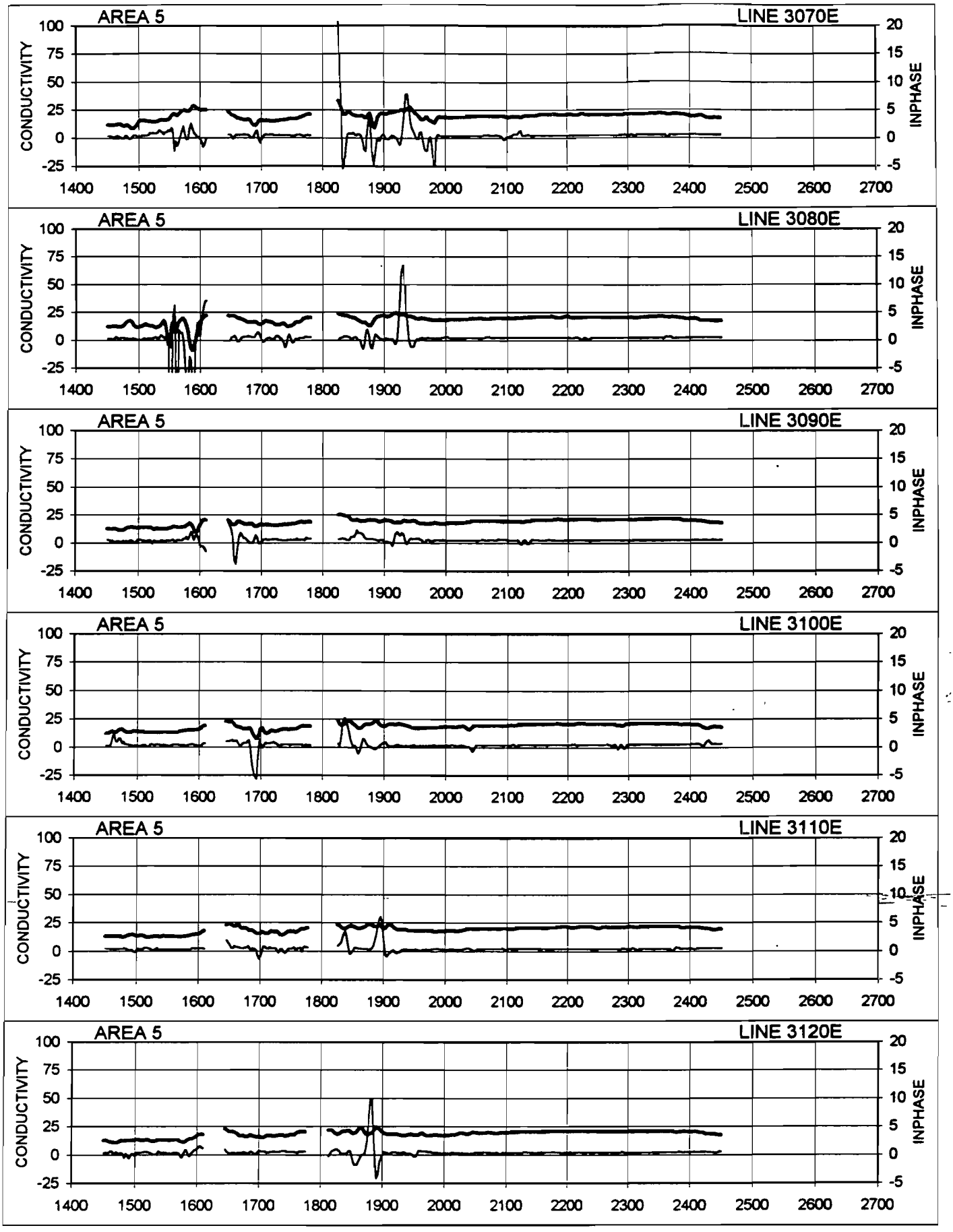
GEOSPHERE MIDWEST

FIGURE H-11



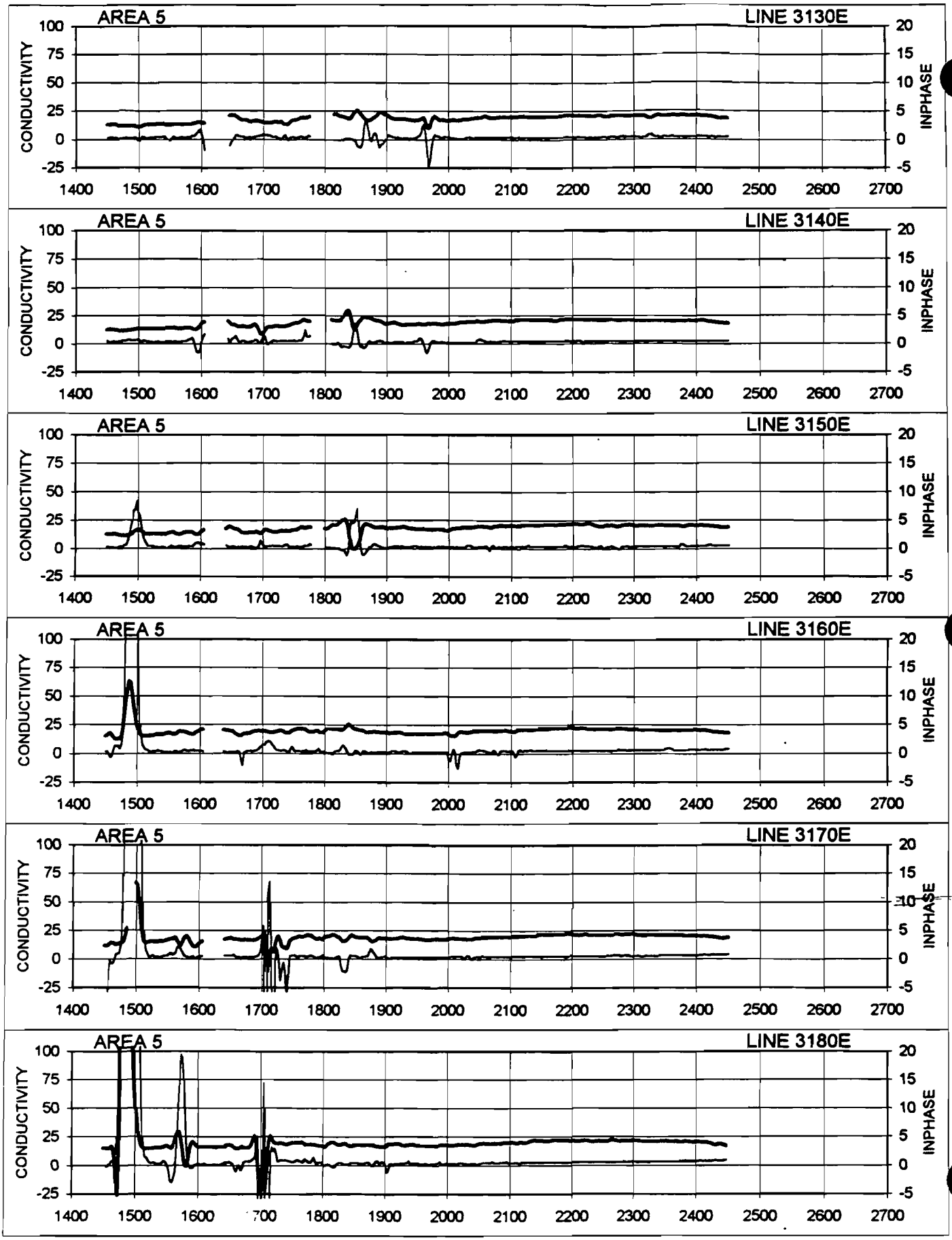
GEOSPHERE MIDWEST

FIGURE H-12



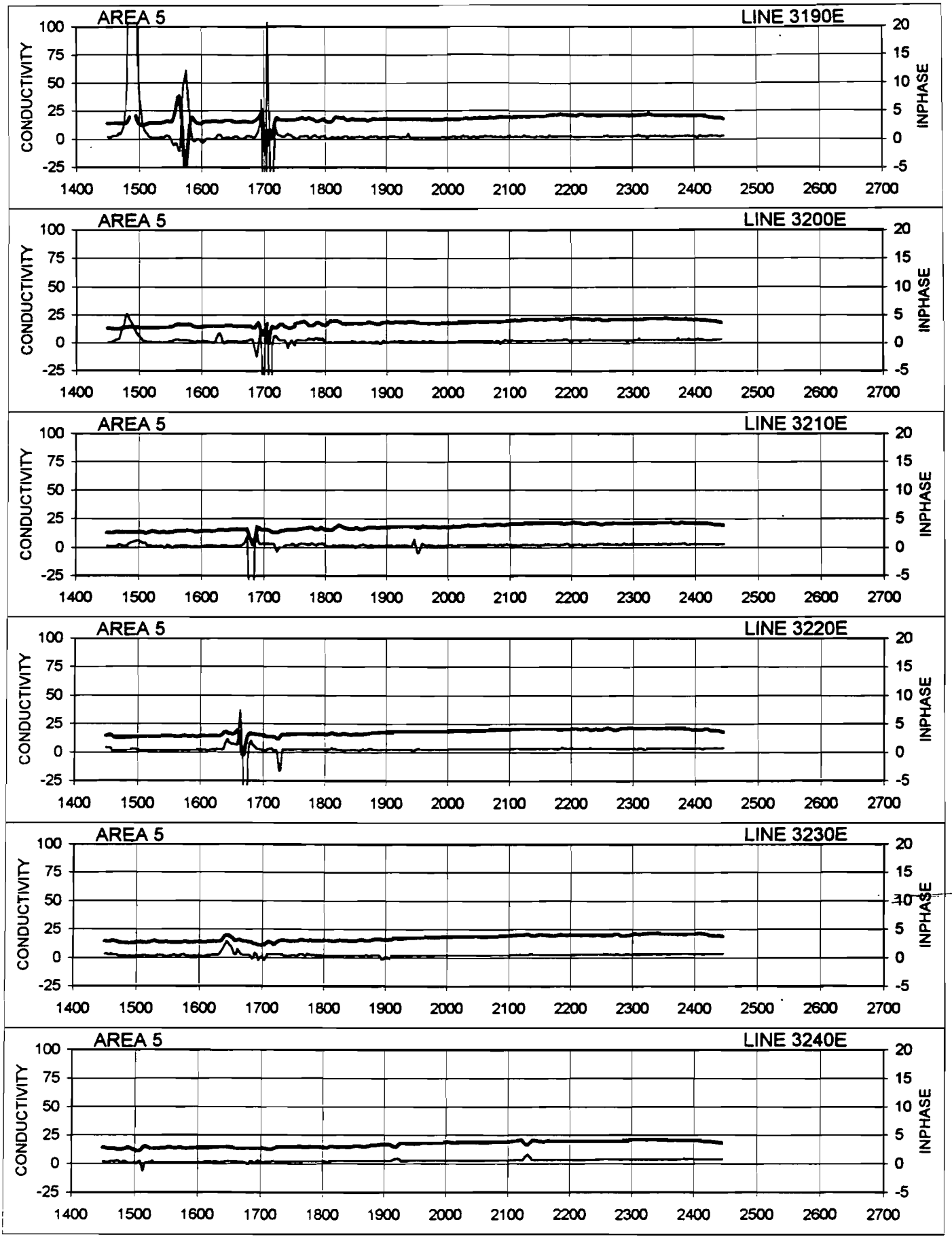
GEOSPHERE MIDWEST

FIGURE H-13



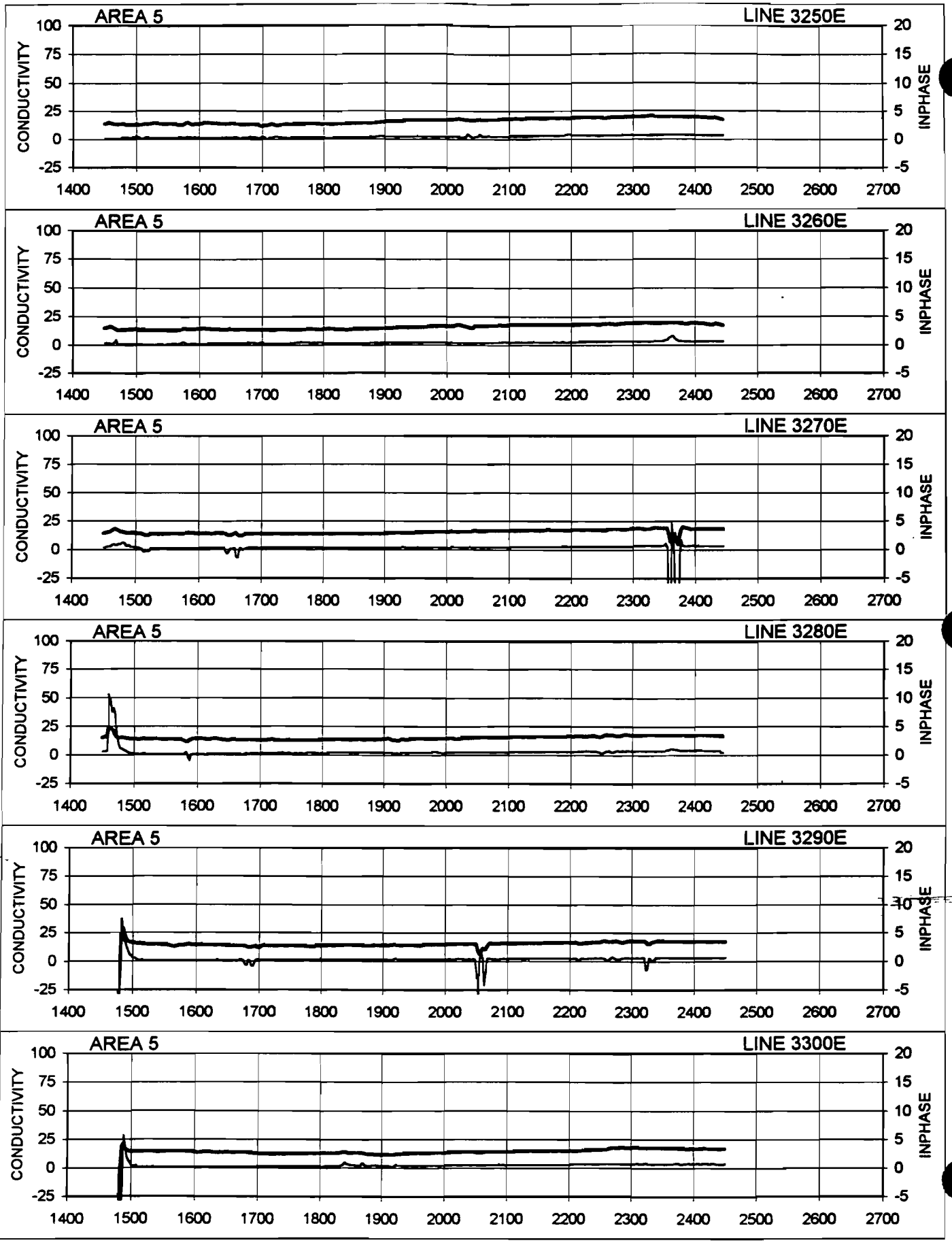
GEOSPHERE MIDWEST

FIGURE H-14



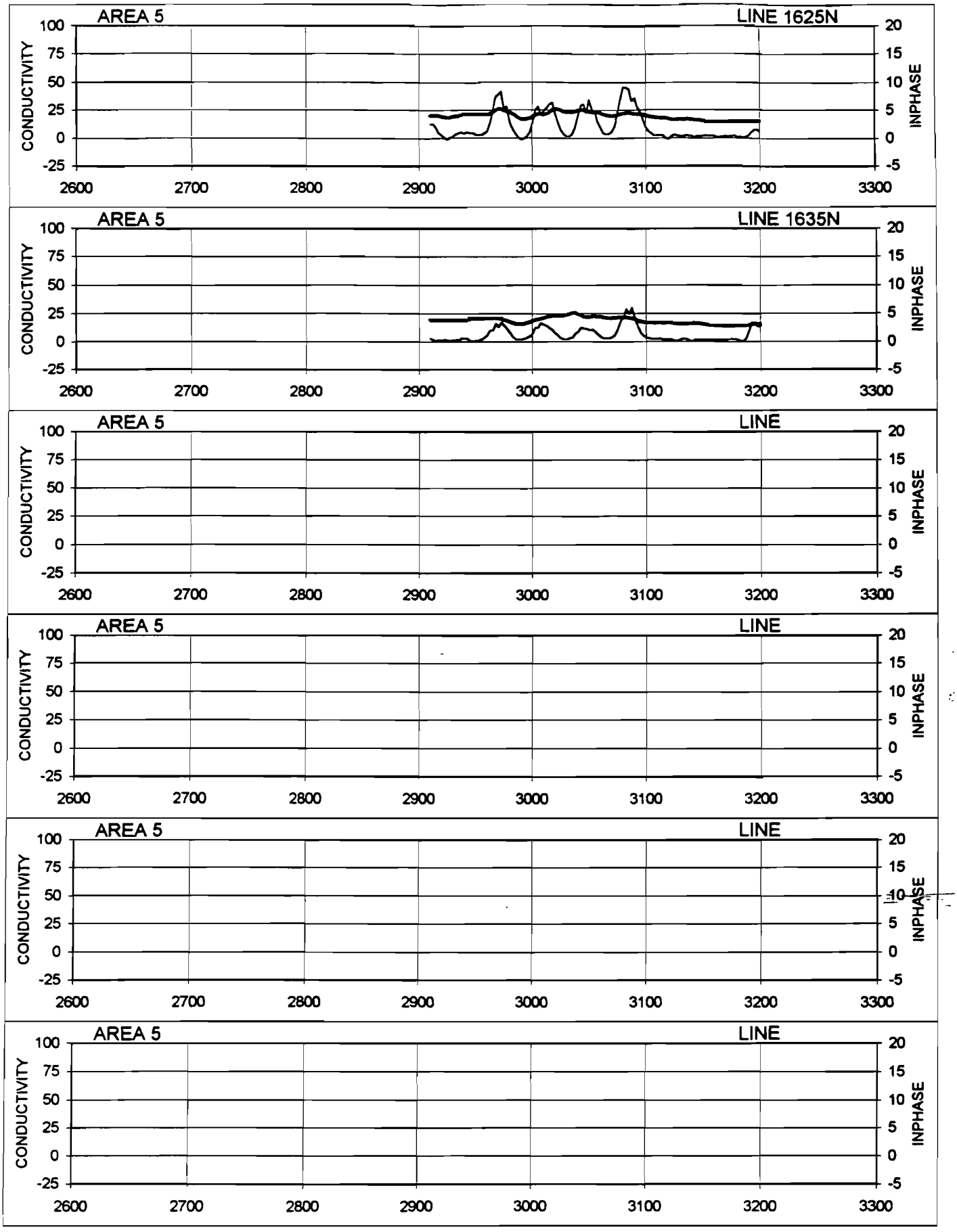
GEOSPHERE MIDWEST

FIGURE H-15



GEOSPHERE MIDWEST

FIGURE H-16



GEOSPHERE MIDWEST

FIGURE H-17

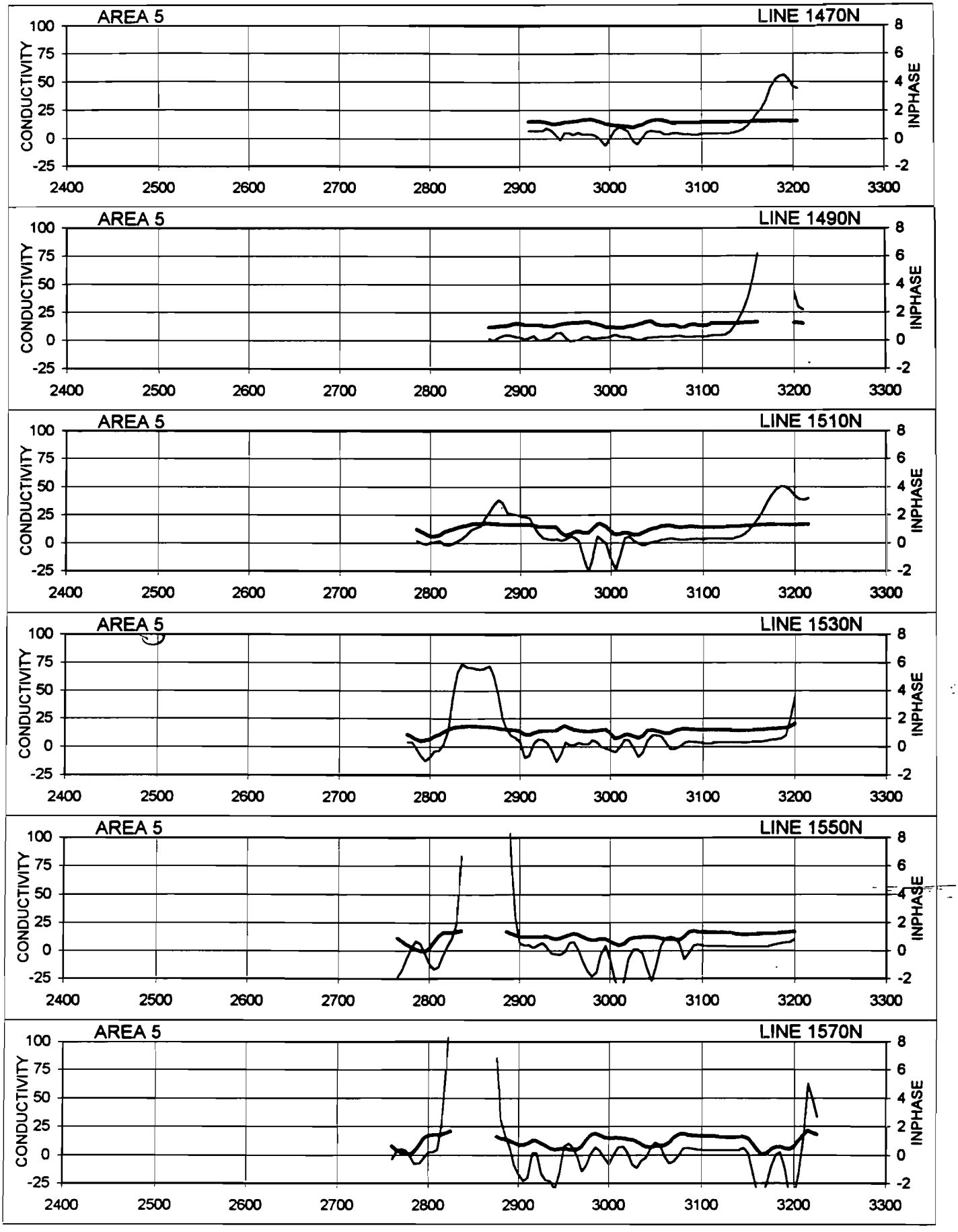
APPENDIX I

SITE 5: EM34 PROFILE DATA

This appendix is a compilation of all EM34 profile data obtained at Site 5. Locations of these EM lines are given in Figure 5.3. The following profiles include line number (northing coordinate), conductivity and inphase (vertical) scales and station location labels (easting coordinates). Conductivity values are given in millimhos/meter (mmhos/m), inphase values are given in parts per thousand (ppt) and location coordinates are in feet.

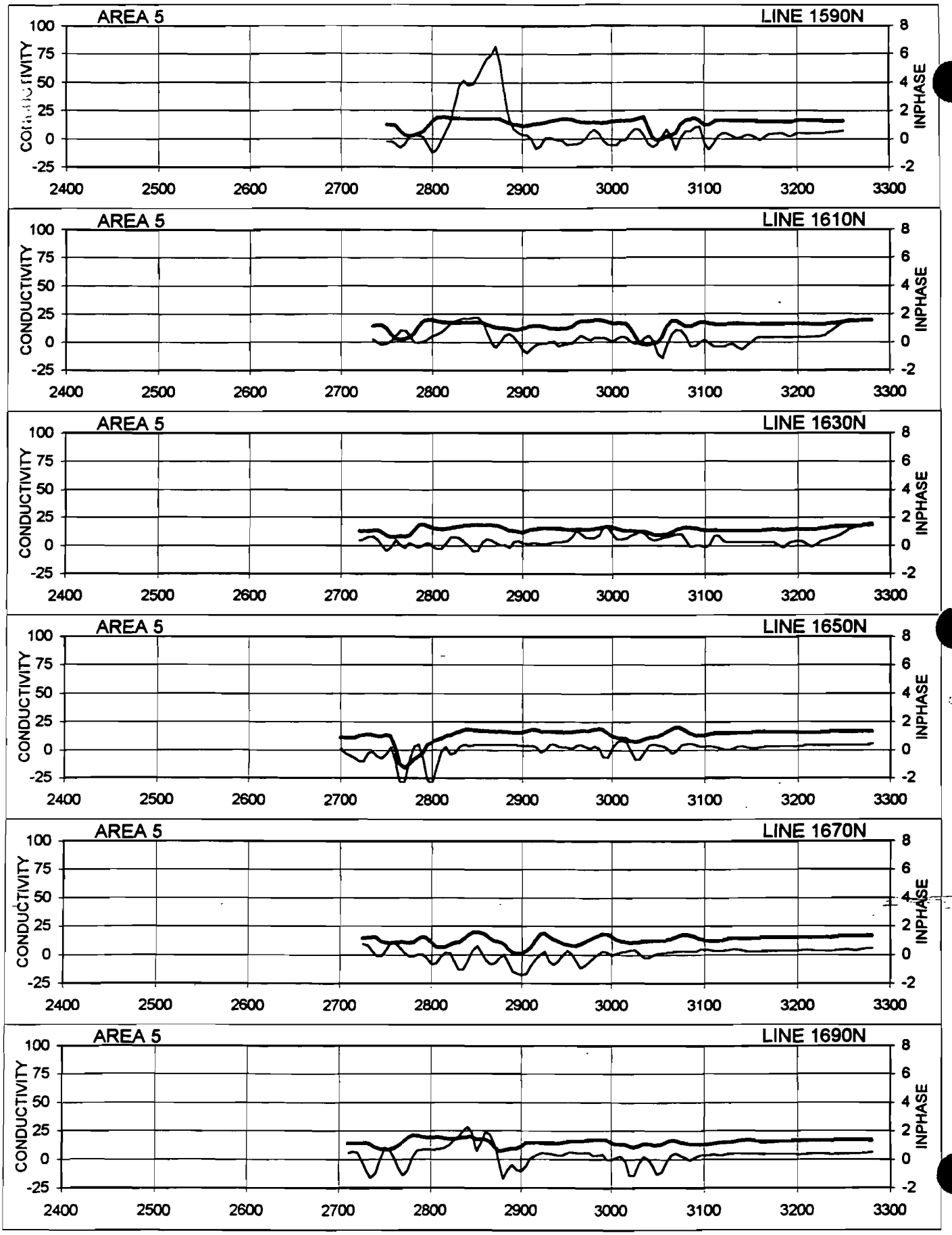
I1. EM34 SURVEY: E-W PROFILES FROM SITE 5

Figures I-1 to I-7



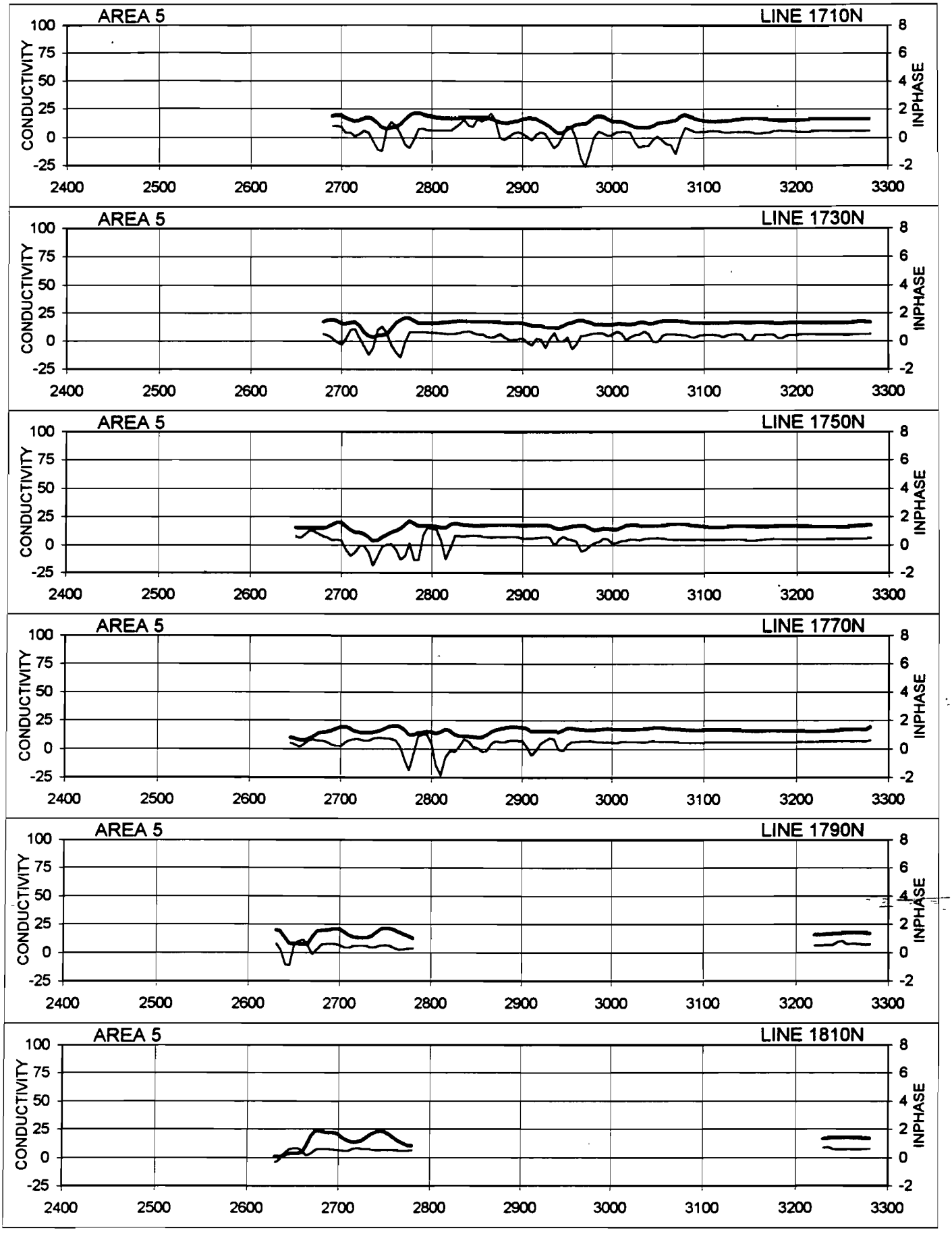
GEOSPHERE MIDWEST

FIGURE I-1



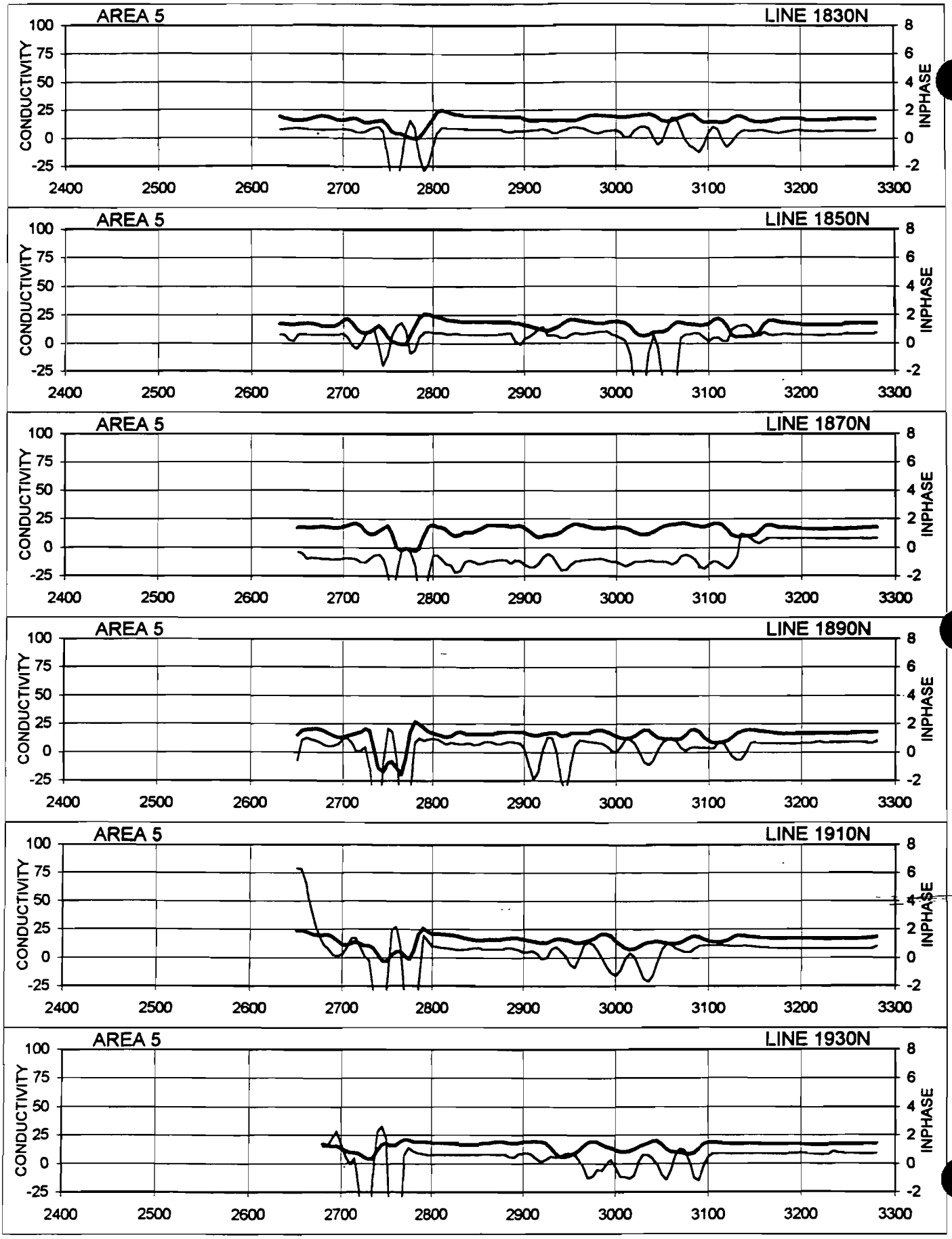
GEOSPHERE MIDWEST

FIGURE I-2



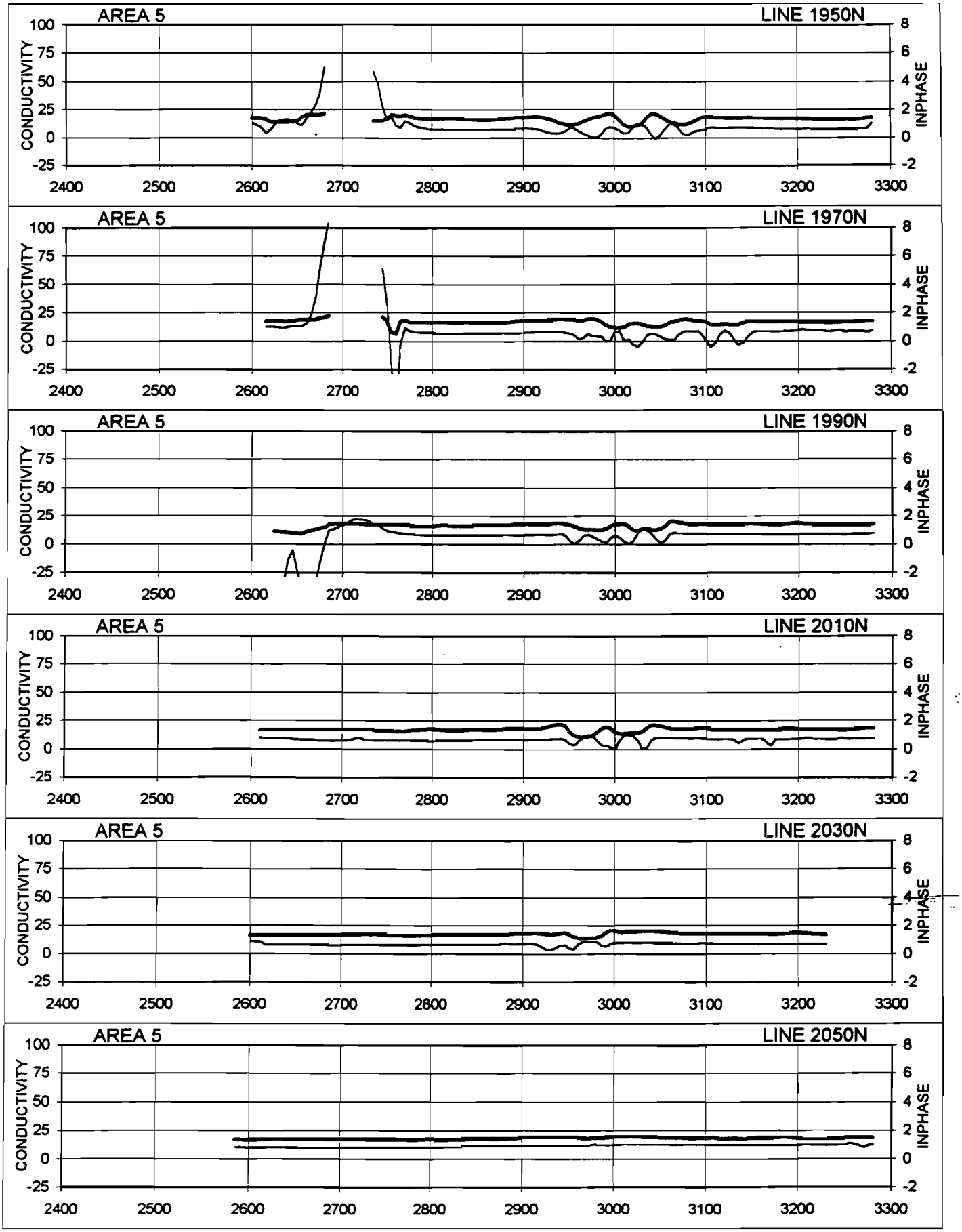
GEOSPHERE MIDWEST

FIGURE I-3



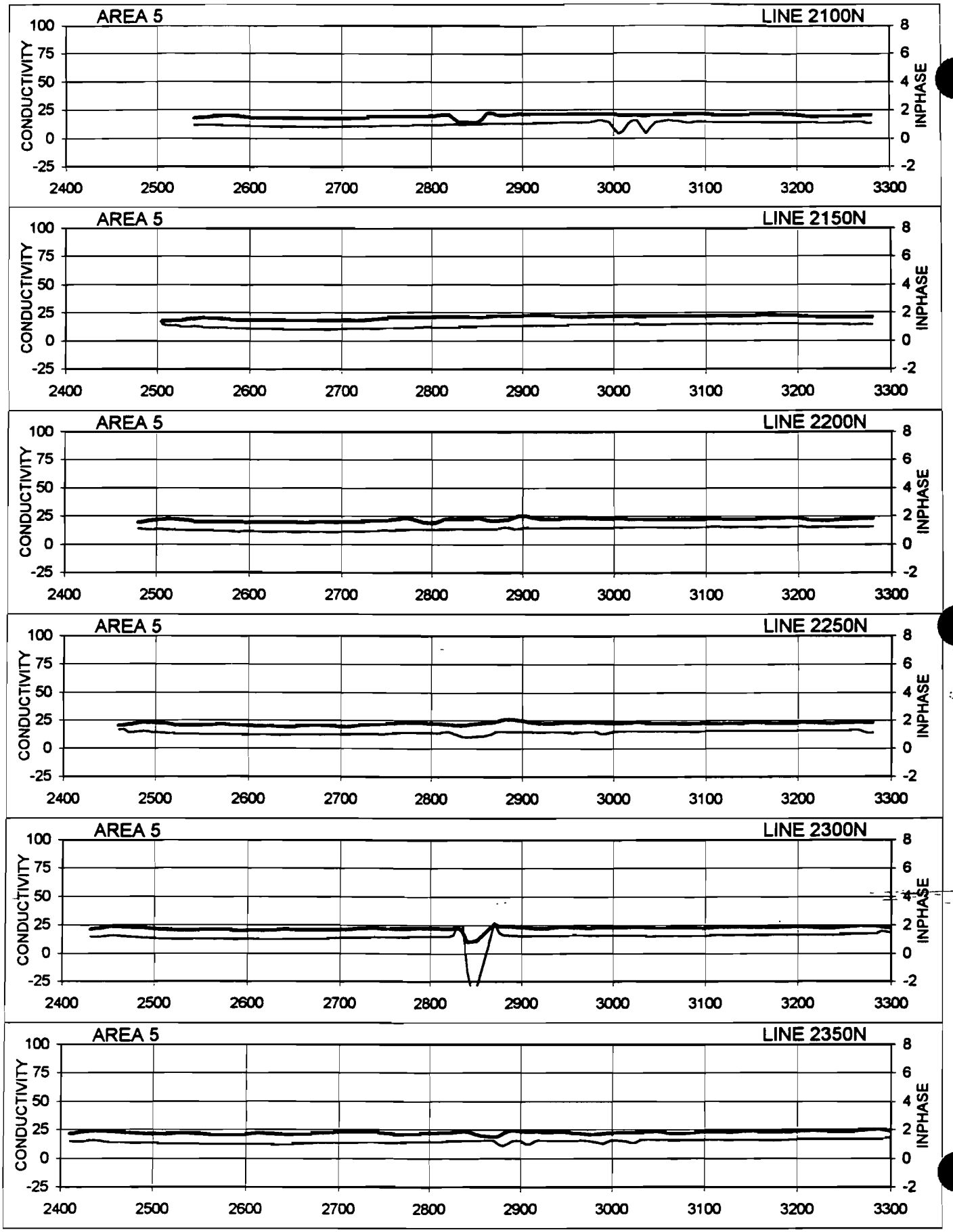
GEOSPHERE MIDWEST

FIGURE I-4



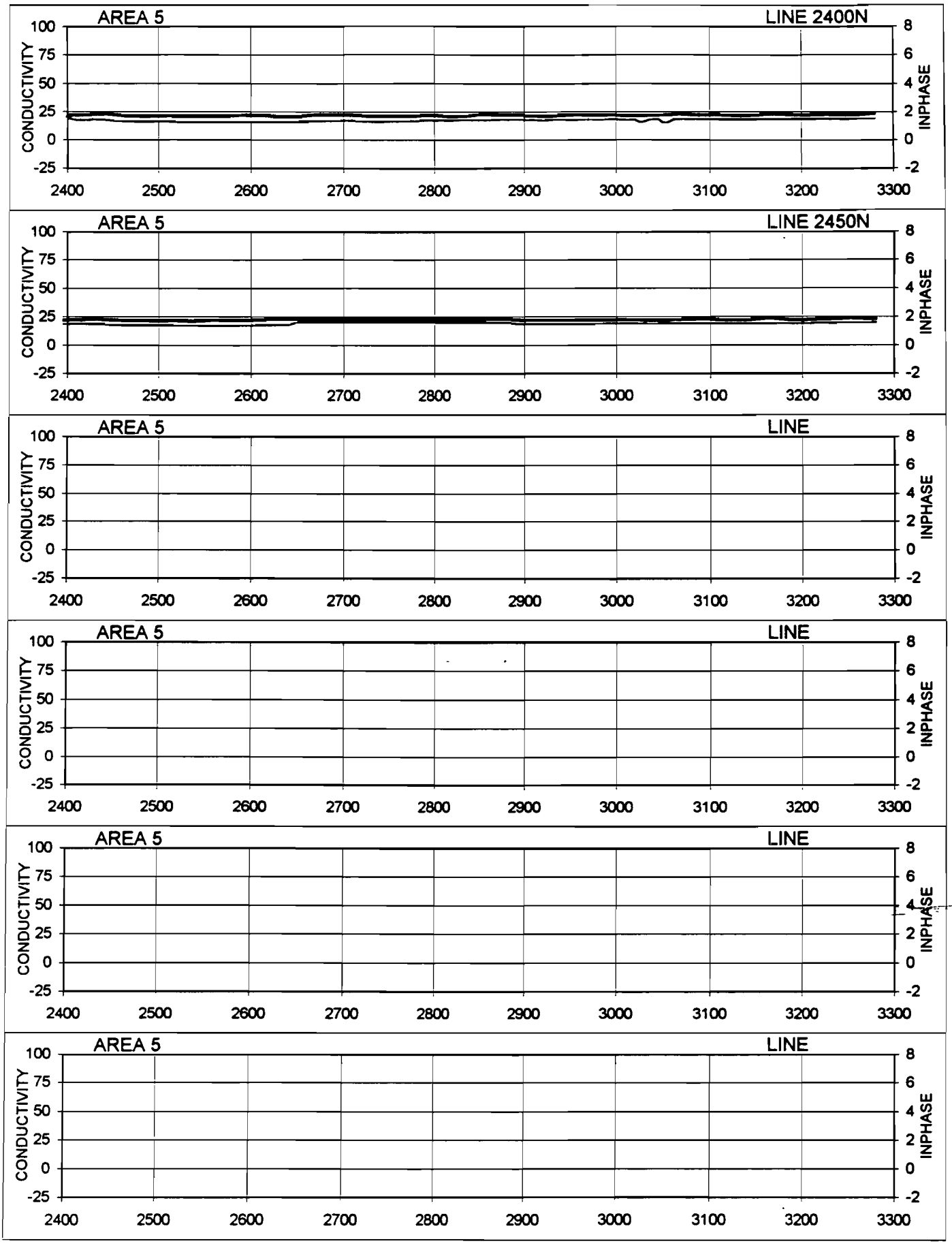
GEOSPHERE MIDWEST

FIGURE I-5



GEOSPHERE MIDWEST

FIGURE I-6



GEOSPHERE MIDWEST

FIGURE I-7

APPENDIX J

SITE 5: EM61 PROFILE DATA

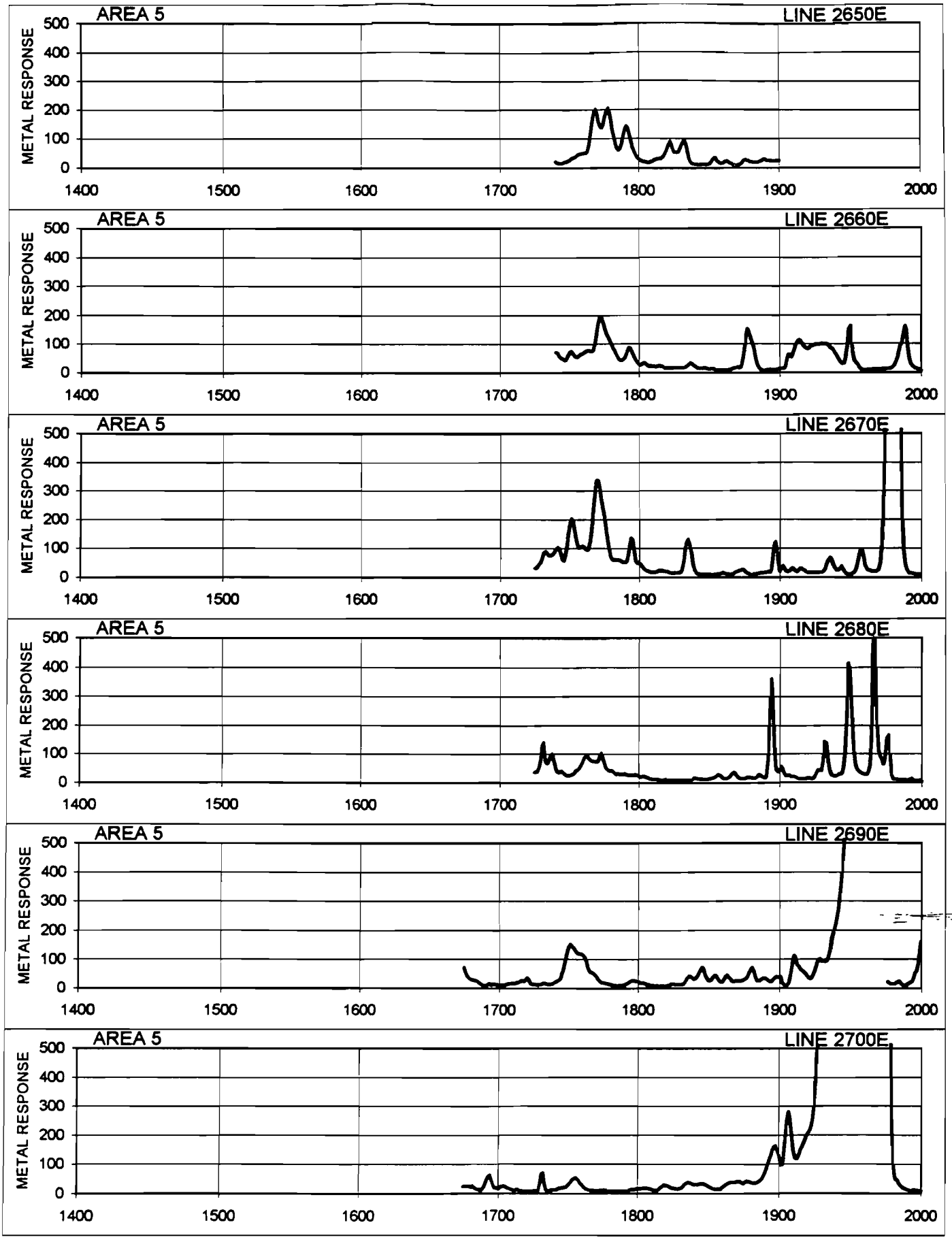
This appendix is a compilation of all EM61 profile data obtained at Site 5. Locations of these EM61 lines are given in Figure 5.4. The following profiles include line number (easting/northing coordinate), metal response (vertical) scales and station location labels (northing/easting coordinates). Metal response values are given in millivolts; location coordinates are in feet.

J1. EM61 SURVEY: N-S PROFILES FROM SITE 5

Figures J-1 to J-11.

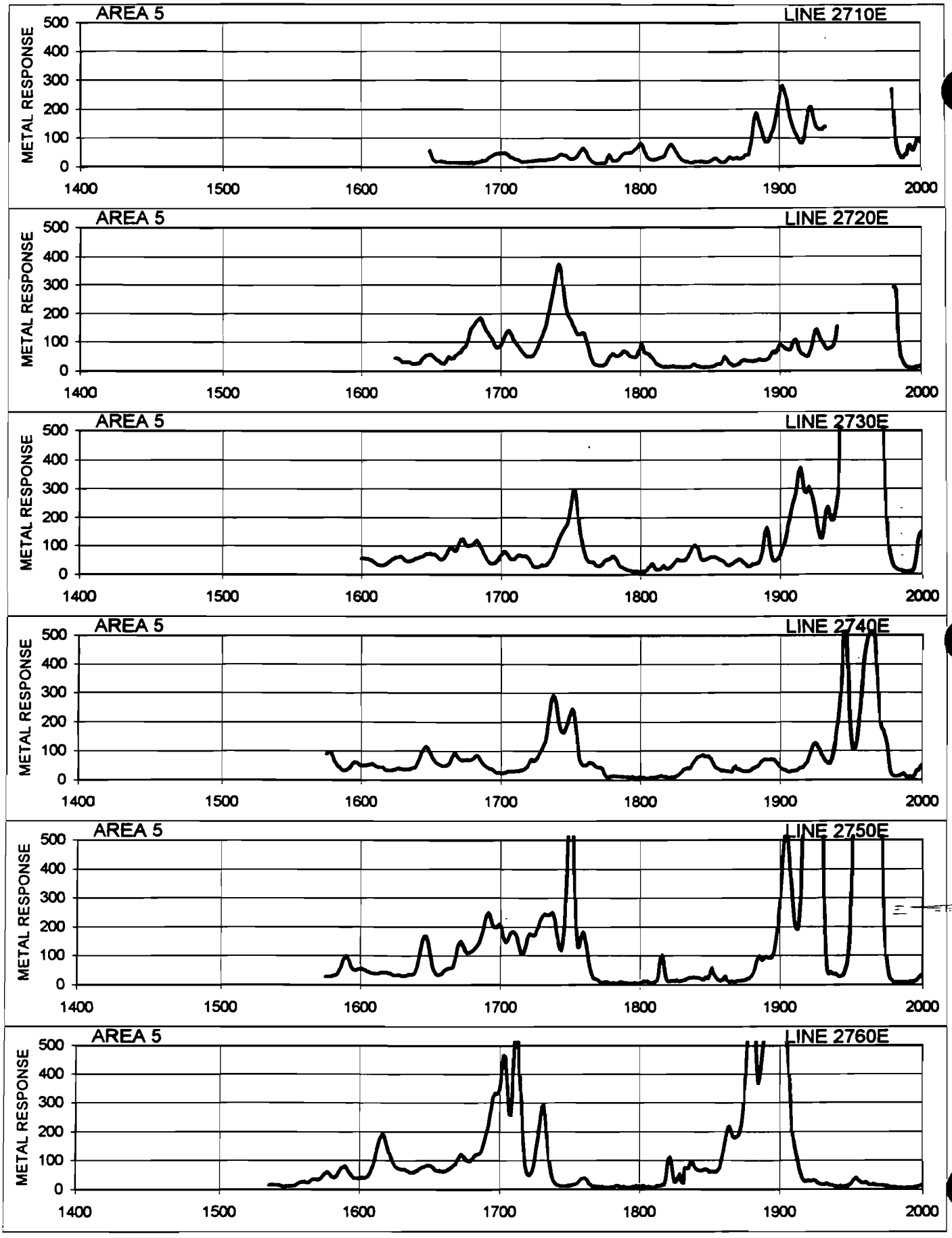
J2. EM61 SURVEY: E-W PROFILES FROM SITE 5

Figures J-13 to J-19.



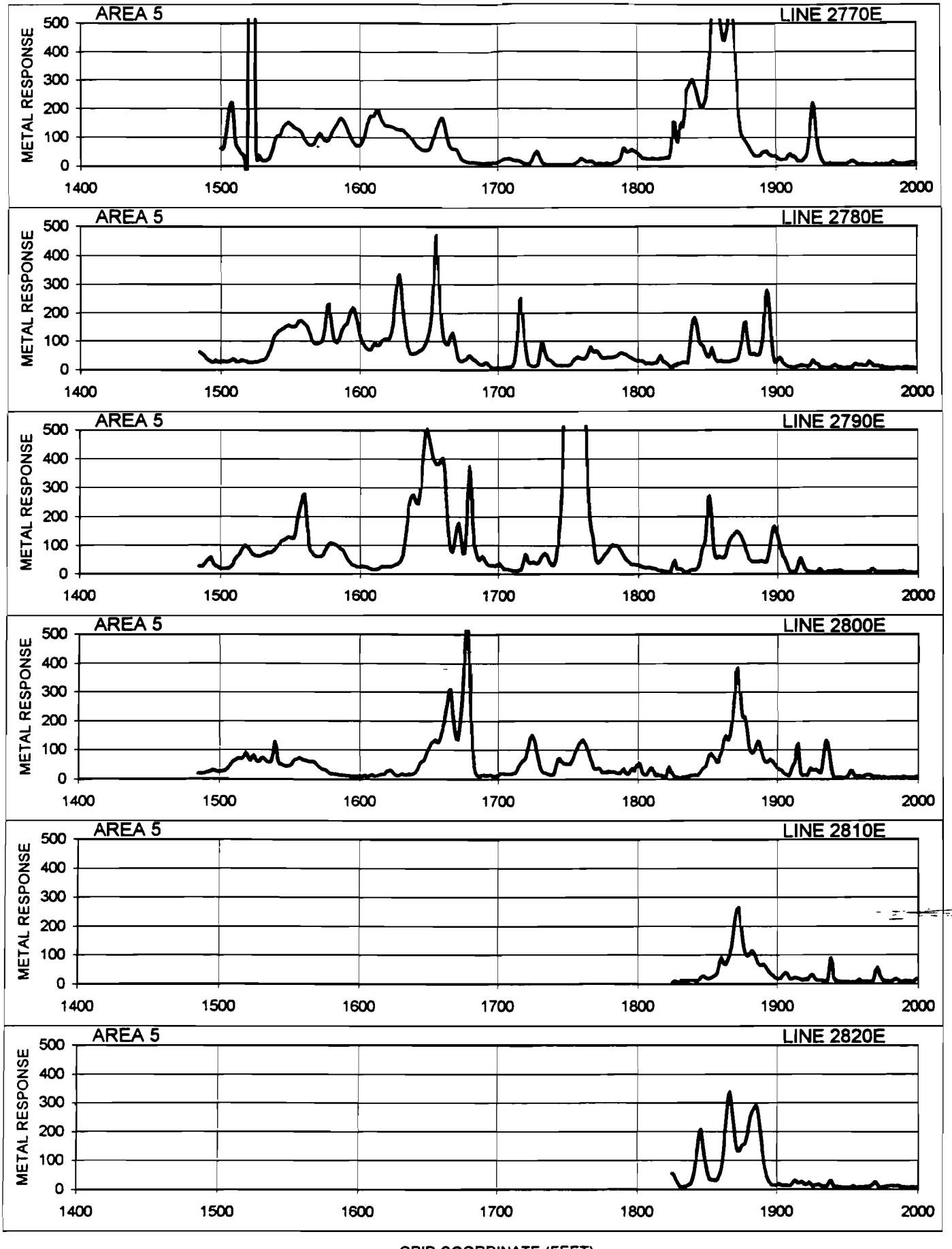
GEOSPHERE MIDWEST

FIGURE J-1



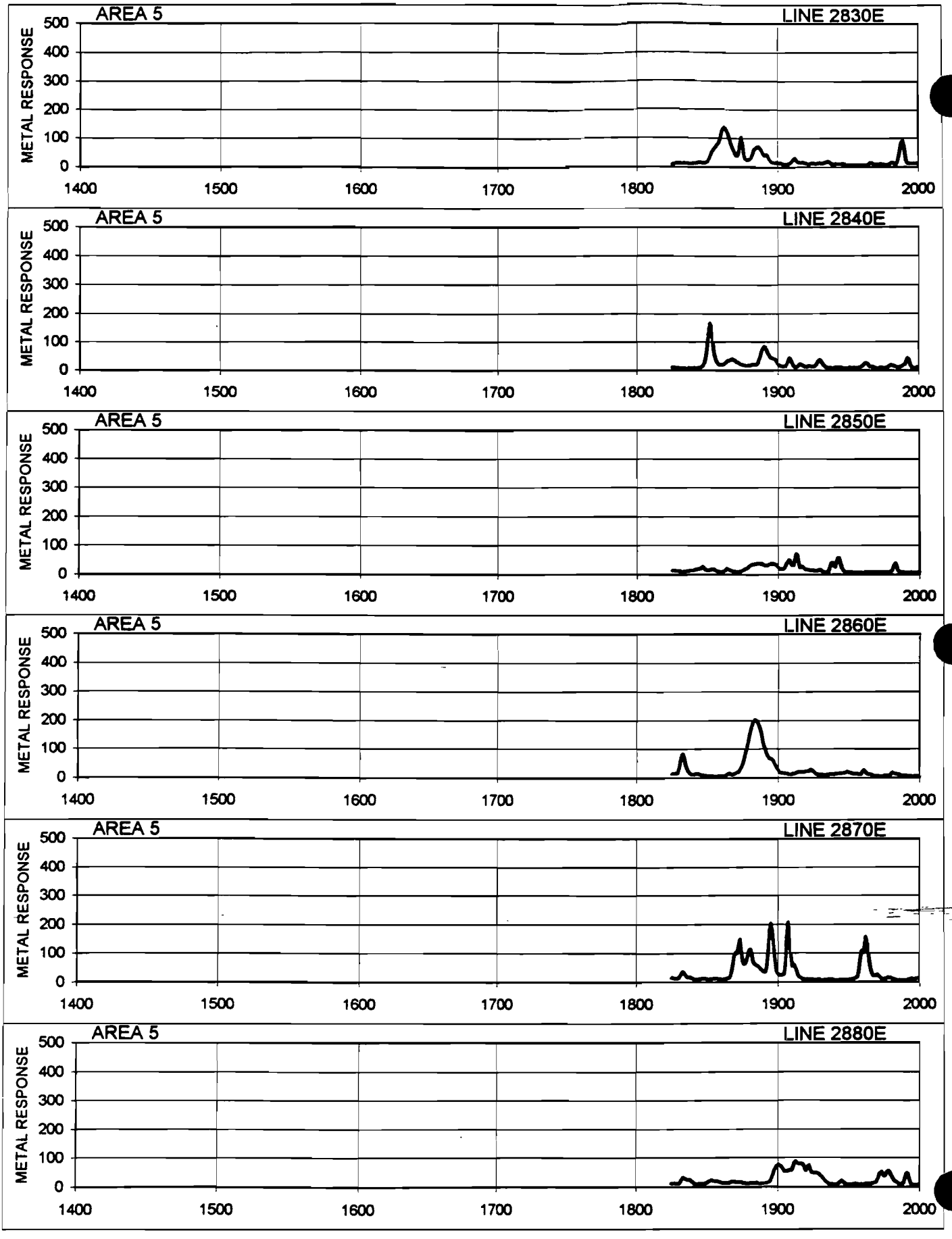
GEOSPHERE MIDWEST

FIGURE J-2



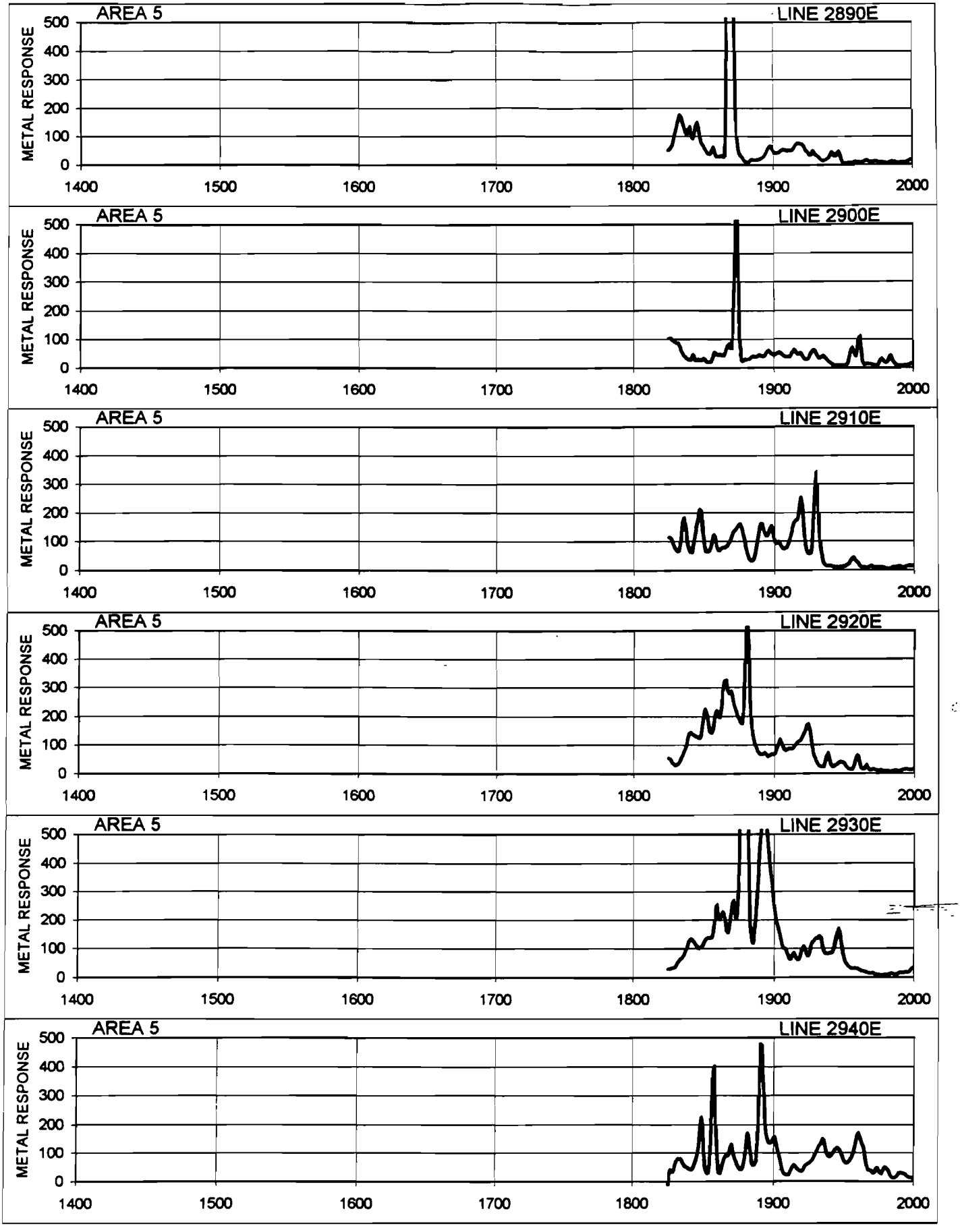
GEOSPHERE MIDWEST

FIGURE J-3



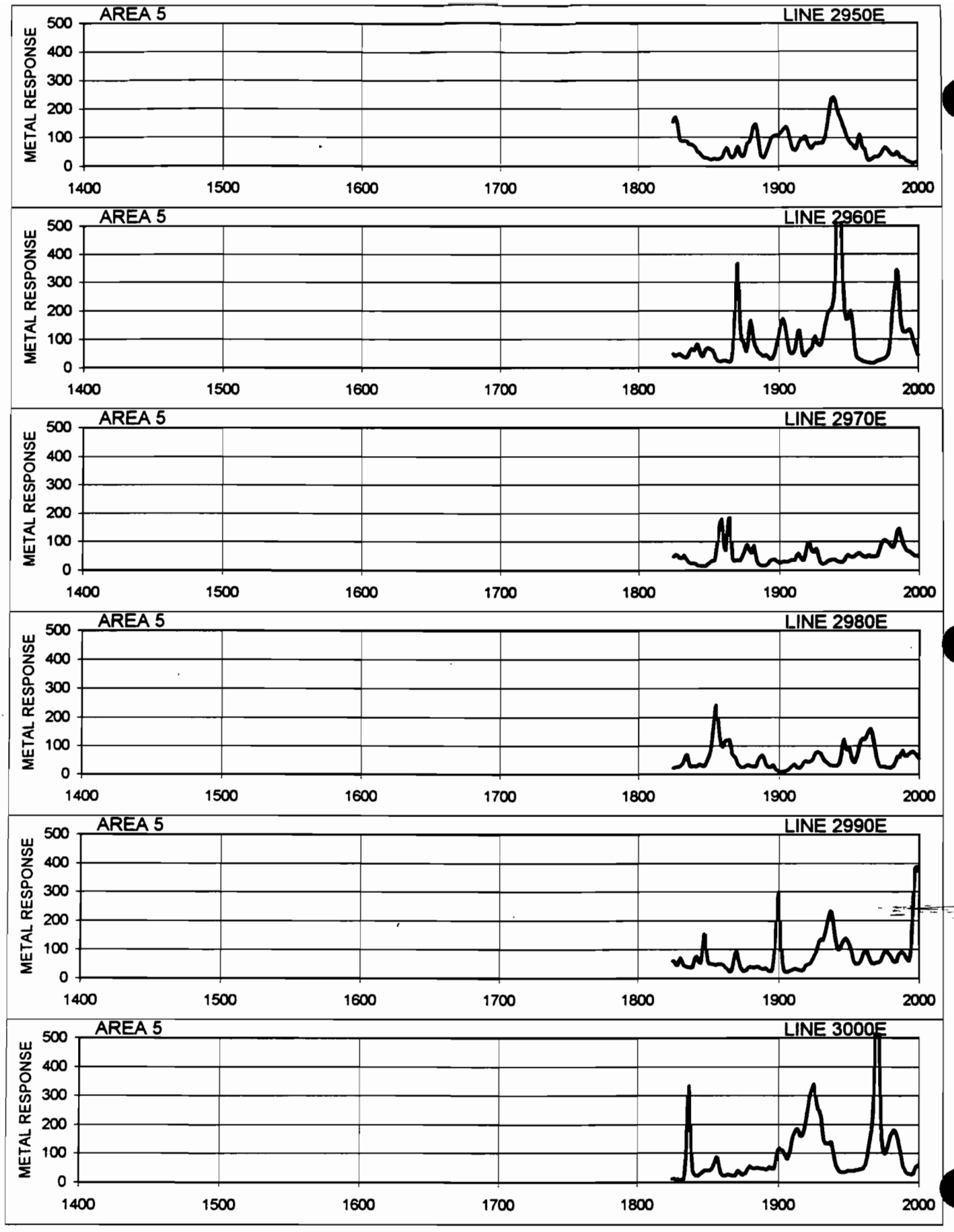
GEOSPHERE MIDWEST

FIGURE J-4



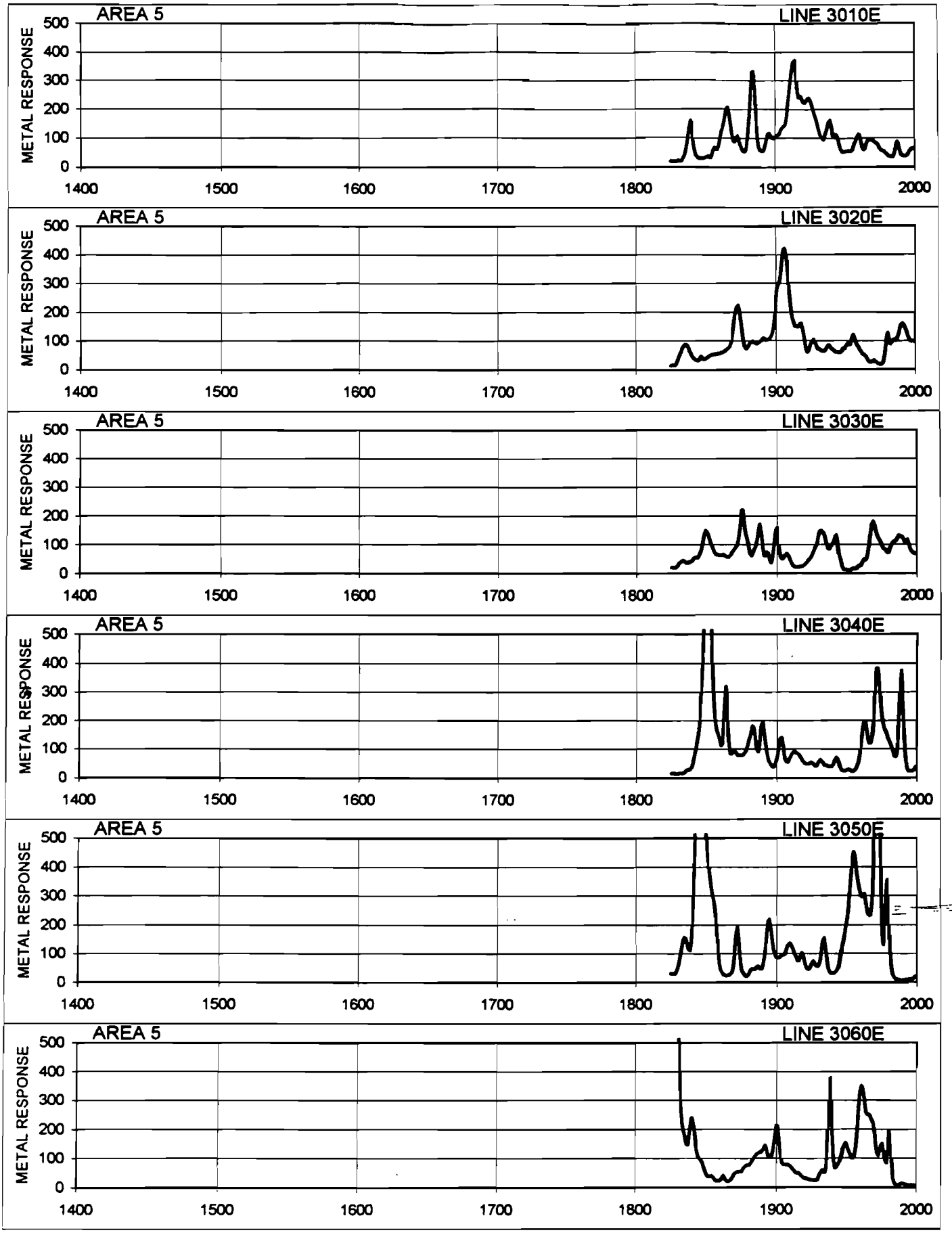
GEOSPHERE MIDWEST

FIGURE J-5



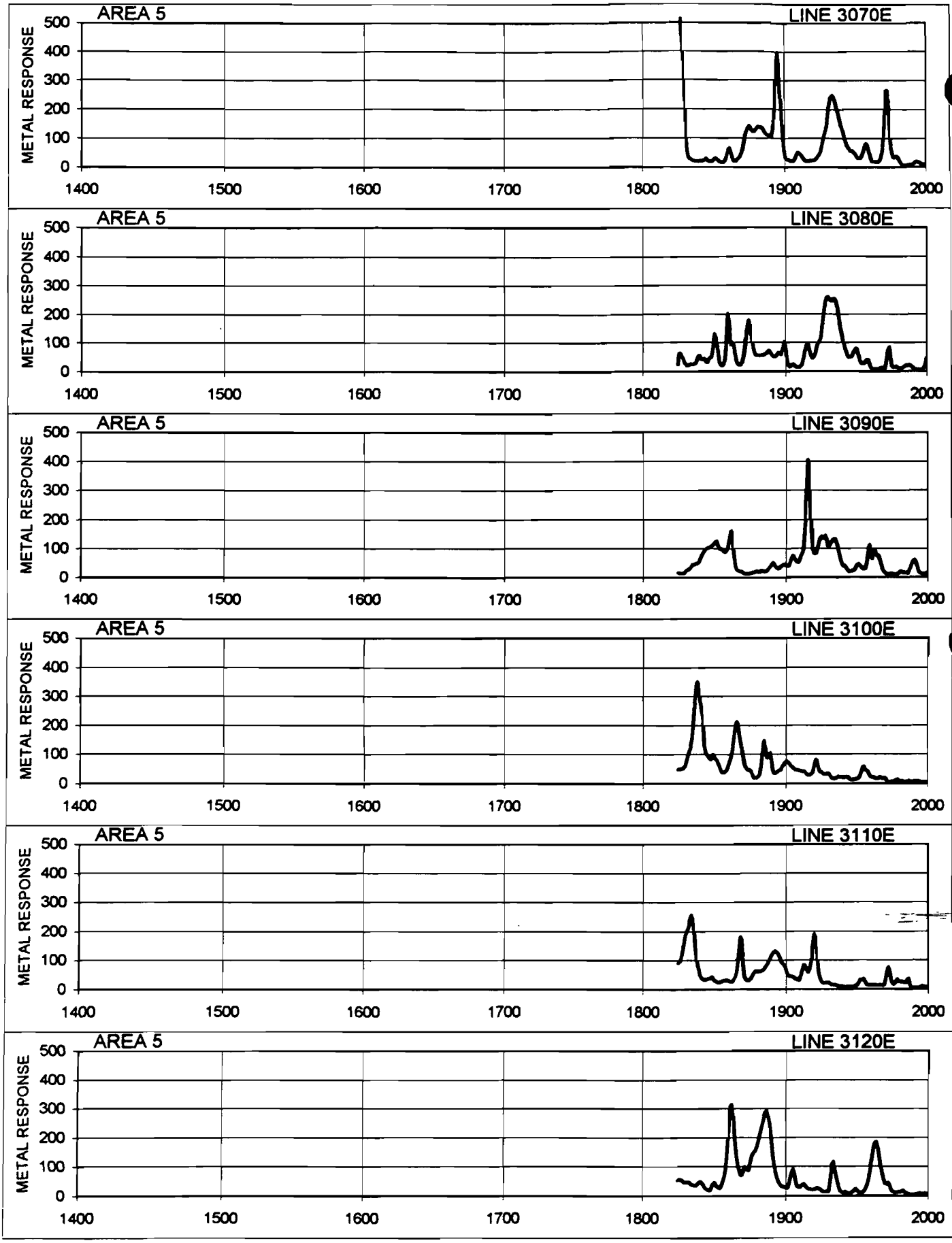
GEOSPHERE MIDWEST

FIGURE J-6



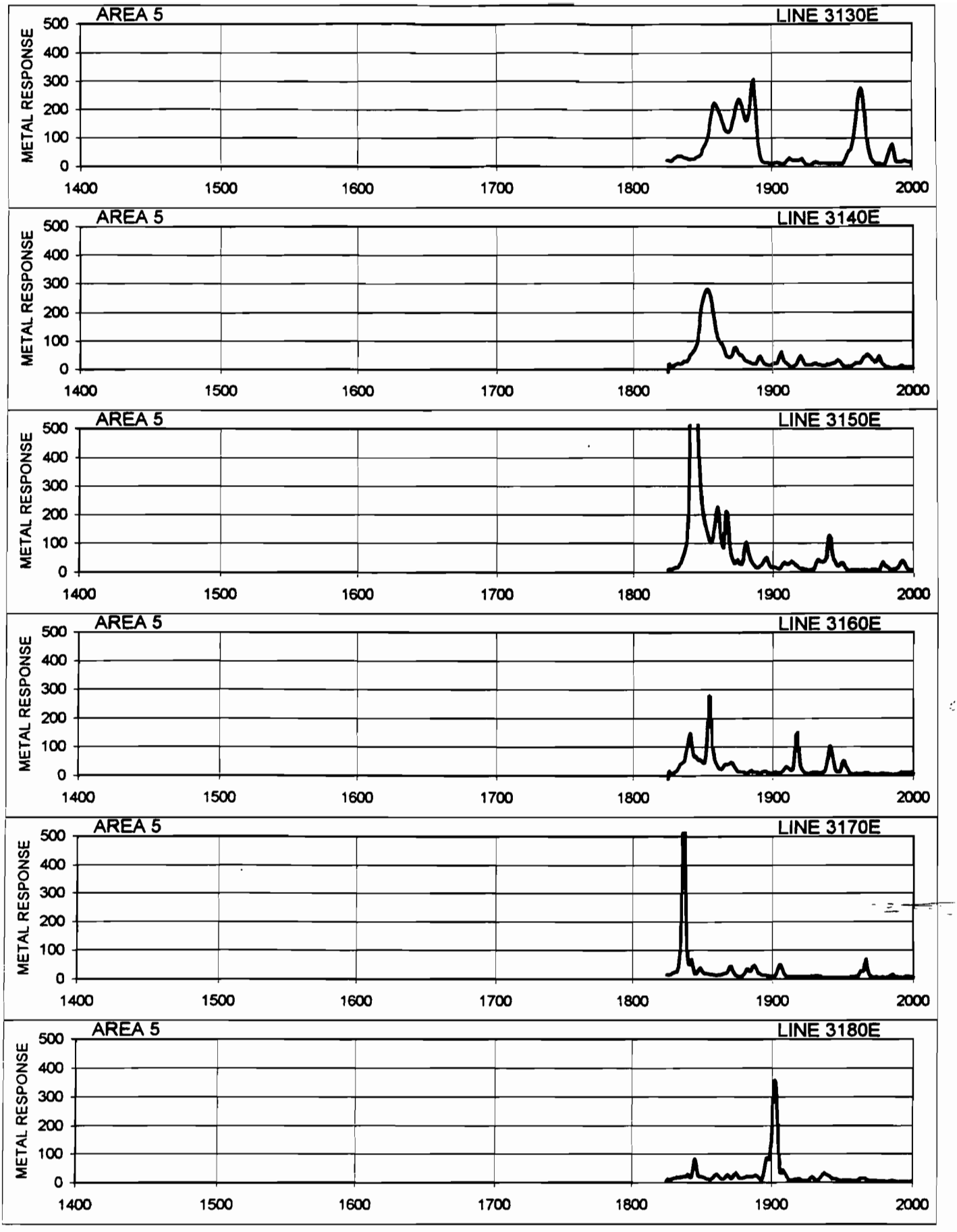
GEOSPHERE MIDWEST

FIGURE J-7



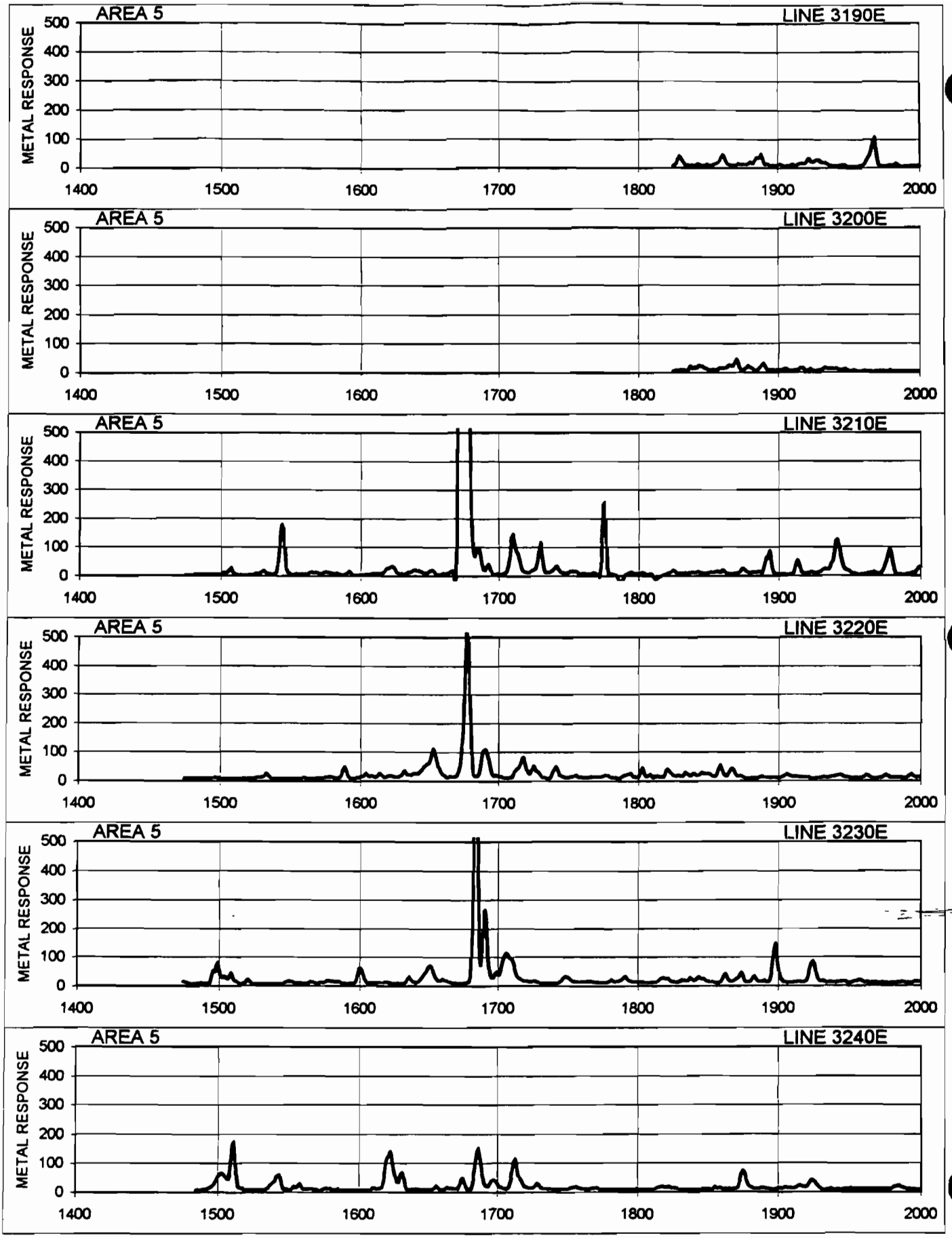
GEOSPHERE MIDWEST

FIGURE J-8



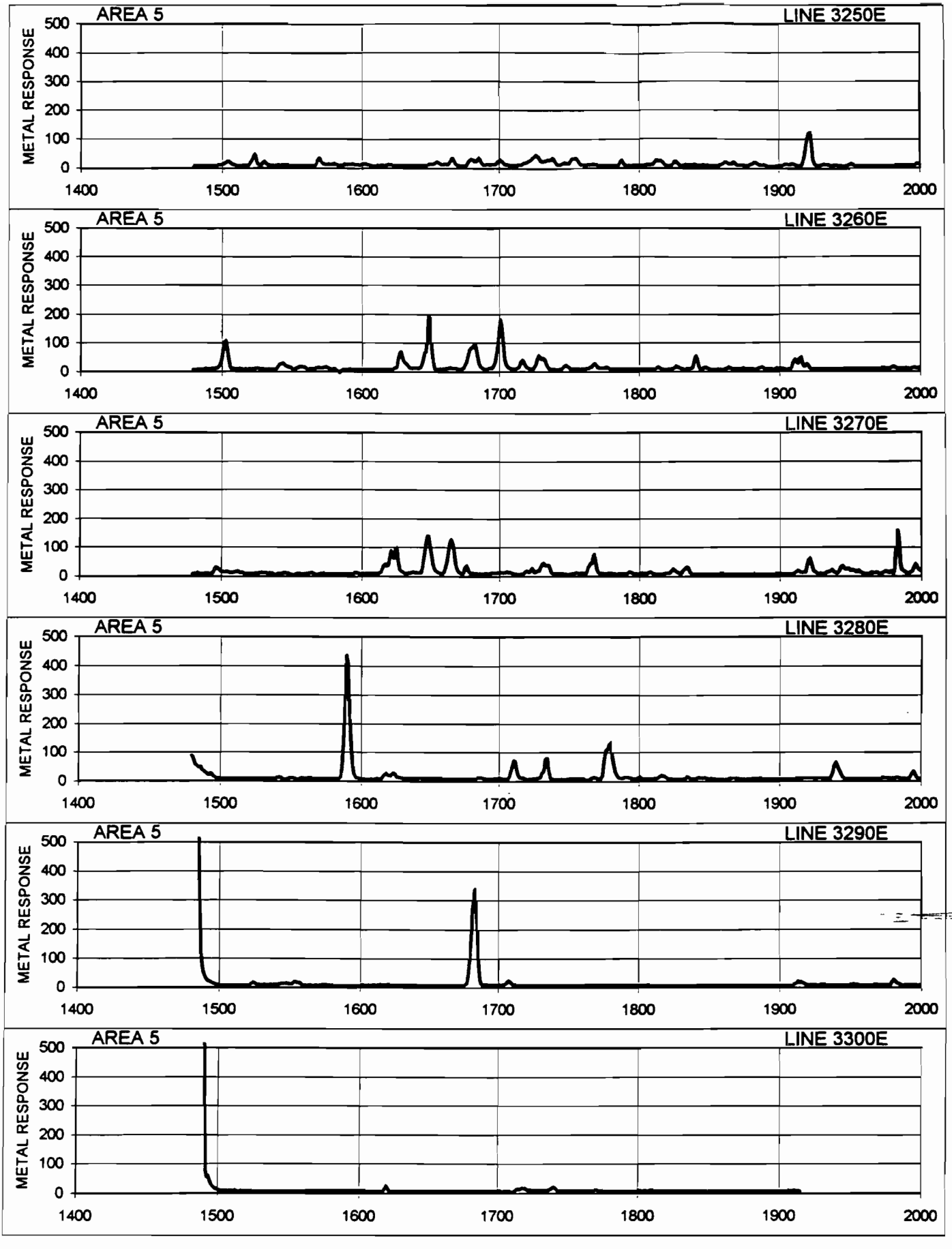
GEOSPHERE MIDWEST

FIGURE J-9



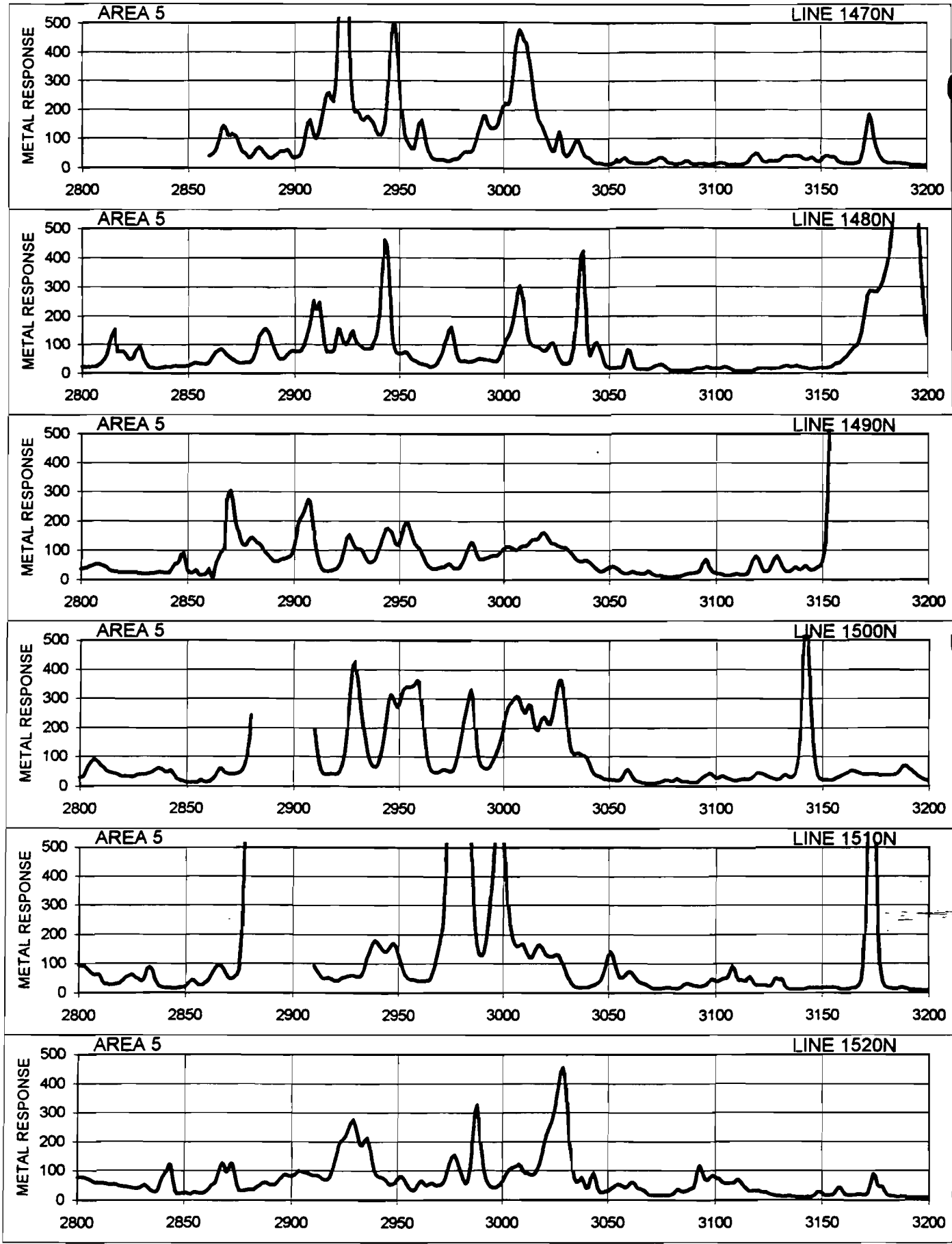
GEOSPHERE MIDWEST

FIGURE J-10



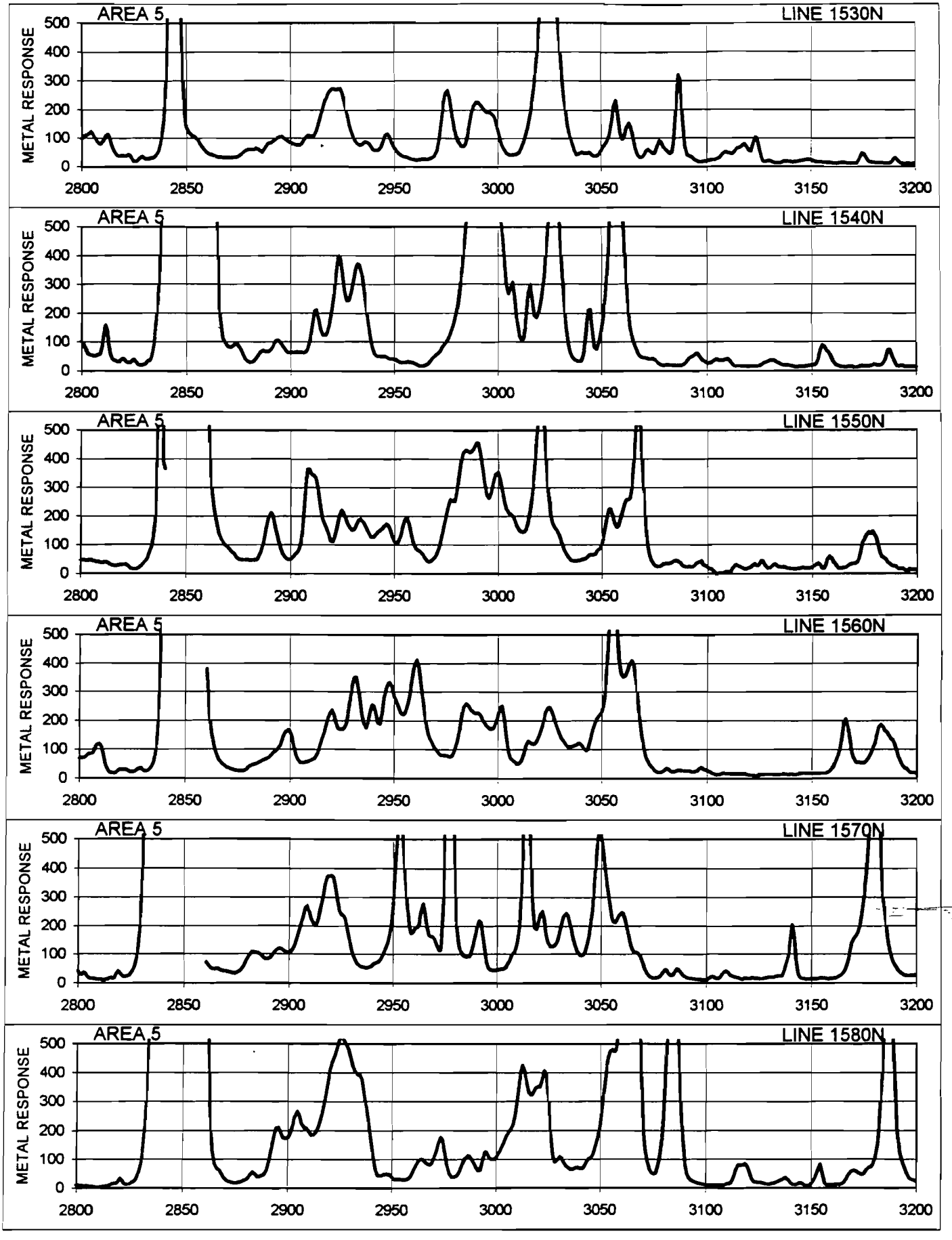
GEOSPHERE MIDWEST

FIGURE J-11



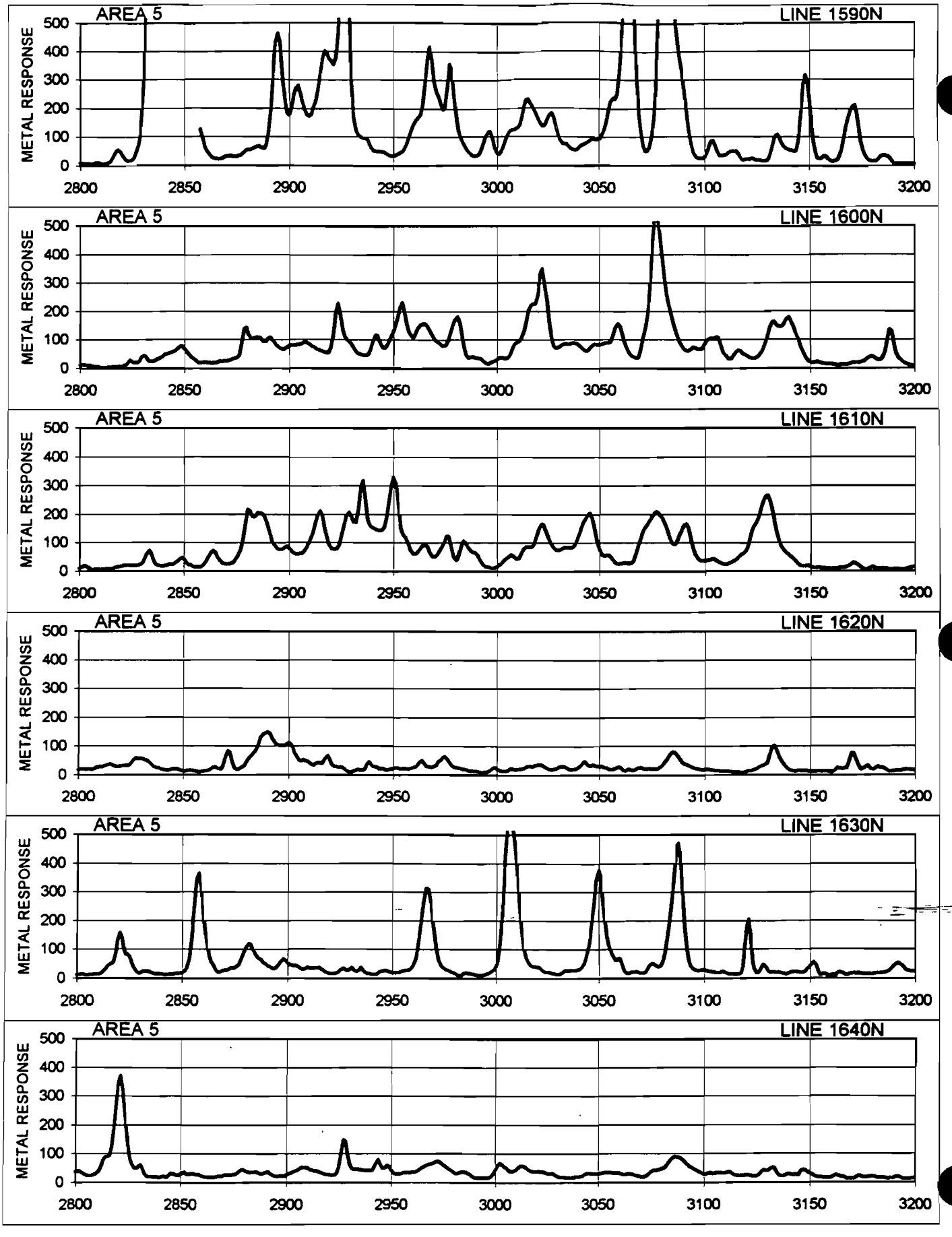
GEOSPHERE MIDWEST

FIGURE J-13



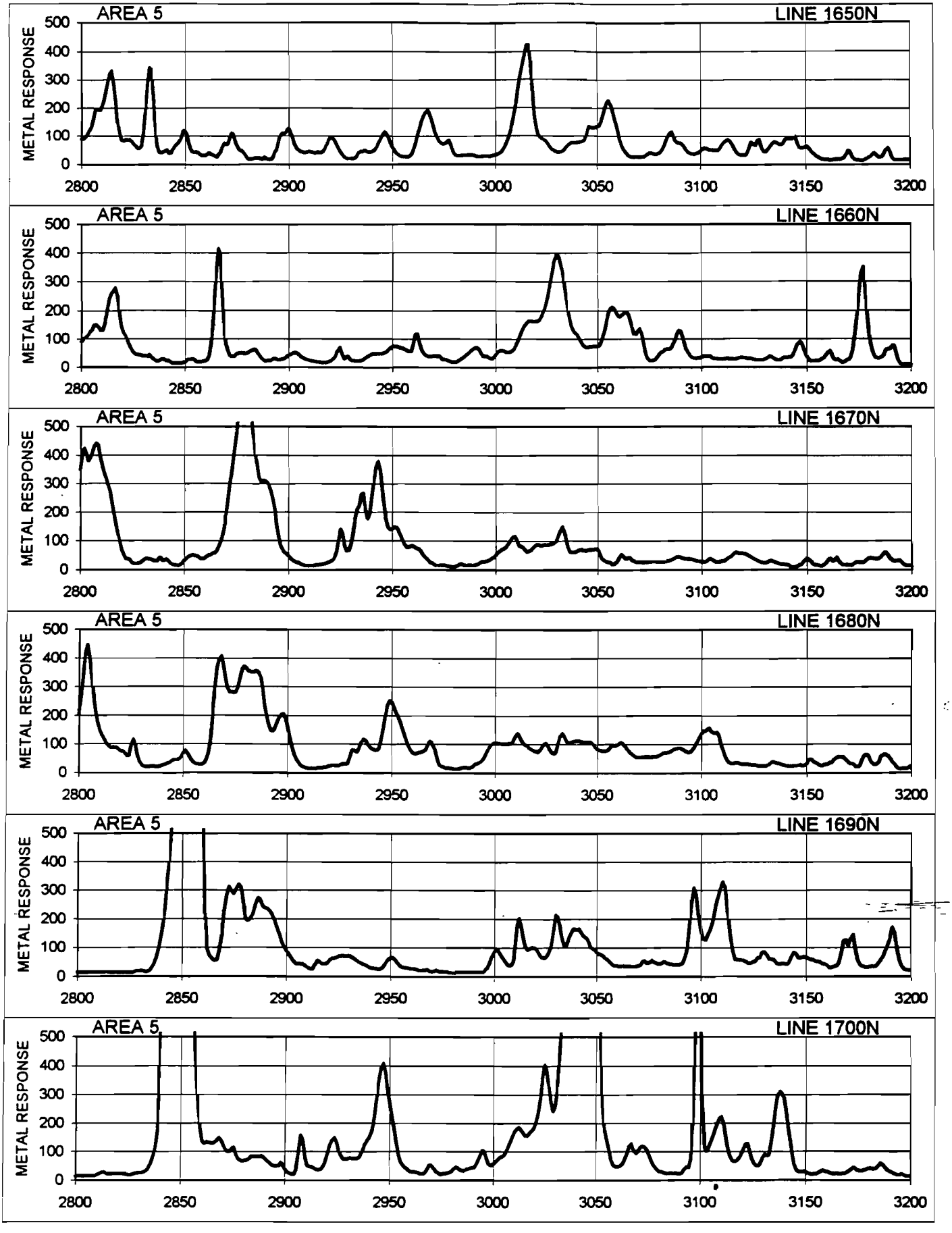
GEOSPHERE MIDWEST

FIGURE J-14



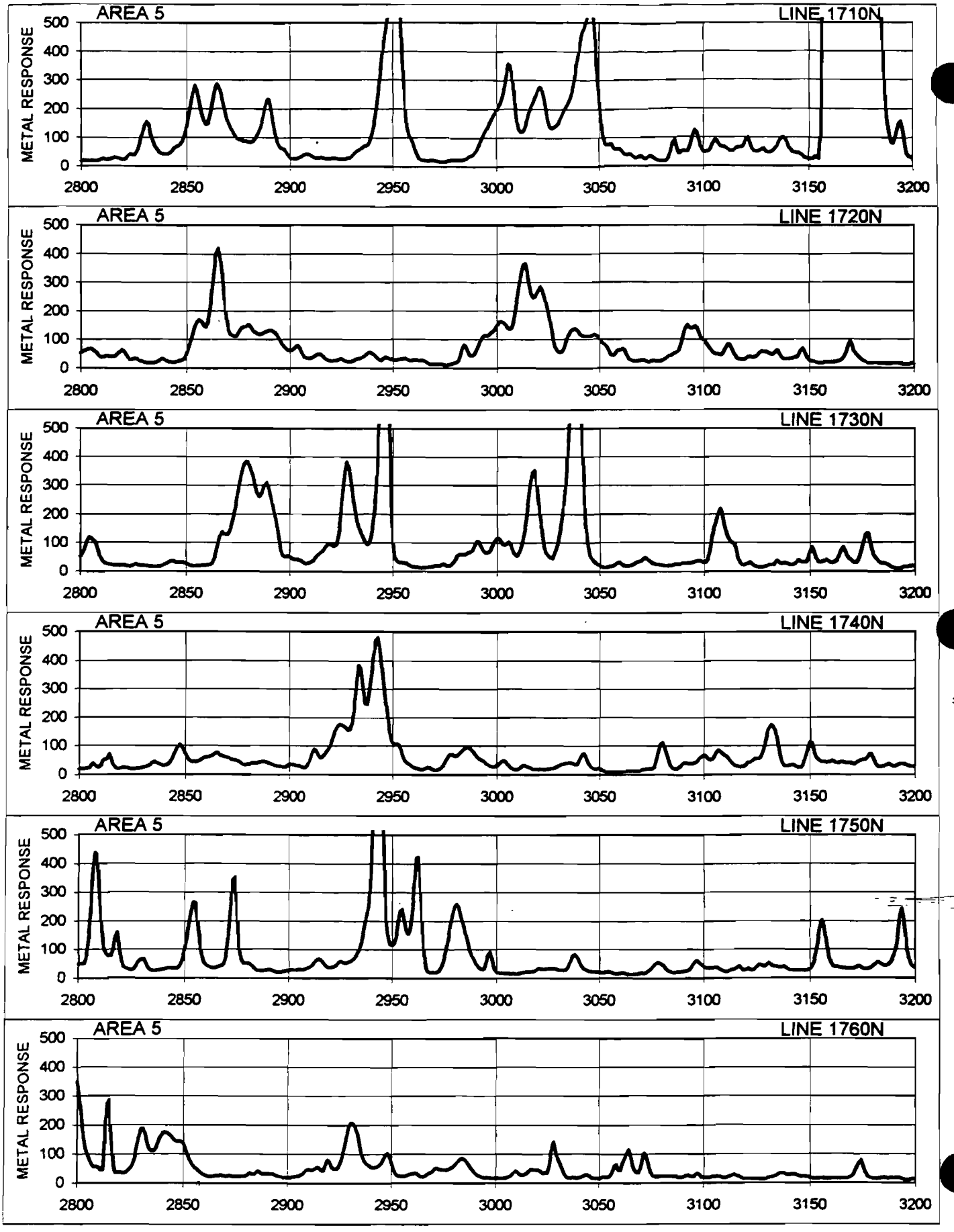
GEOSPHERE MIDWEST

FIGURE J-15



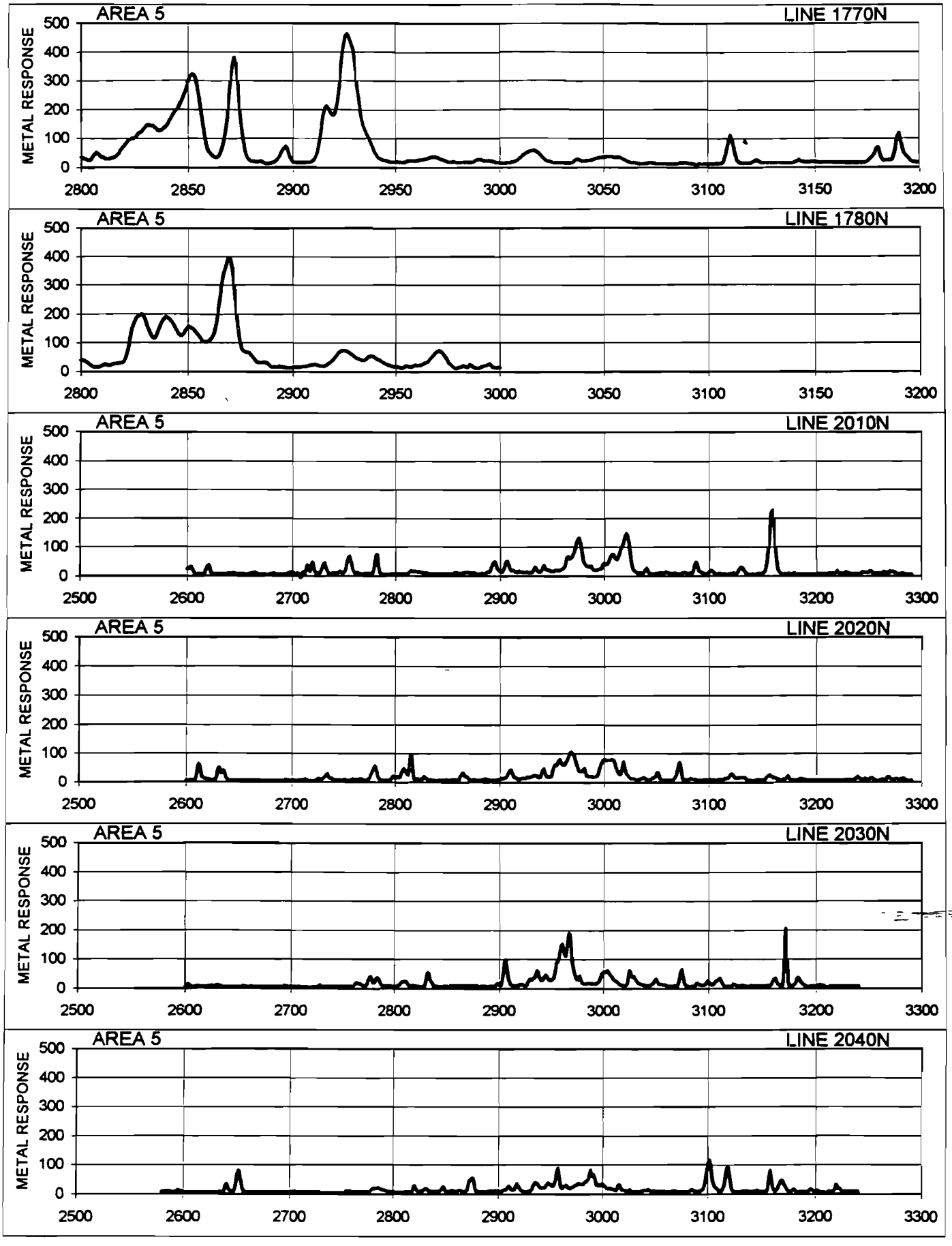
GEOSPHERE MIDWEST

FIGURE J-16



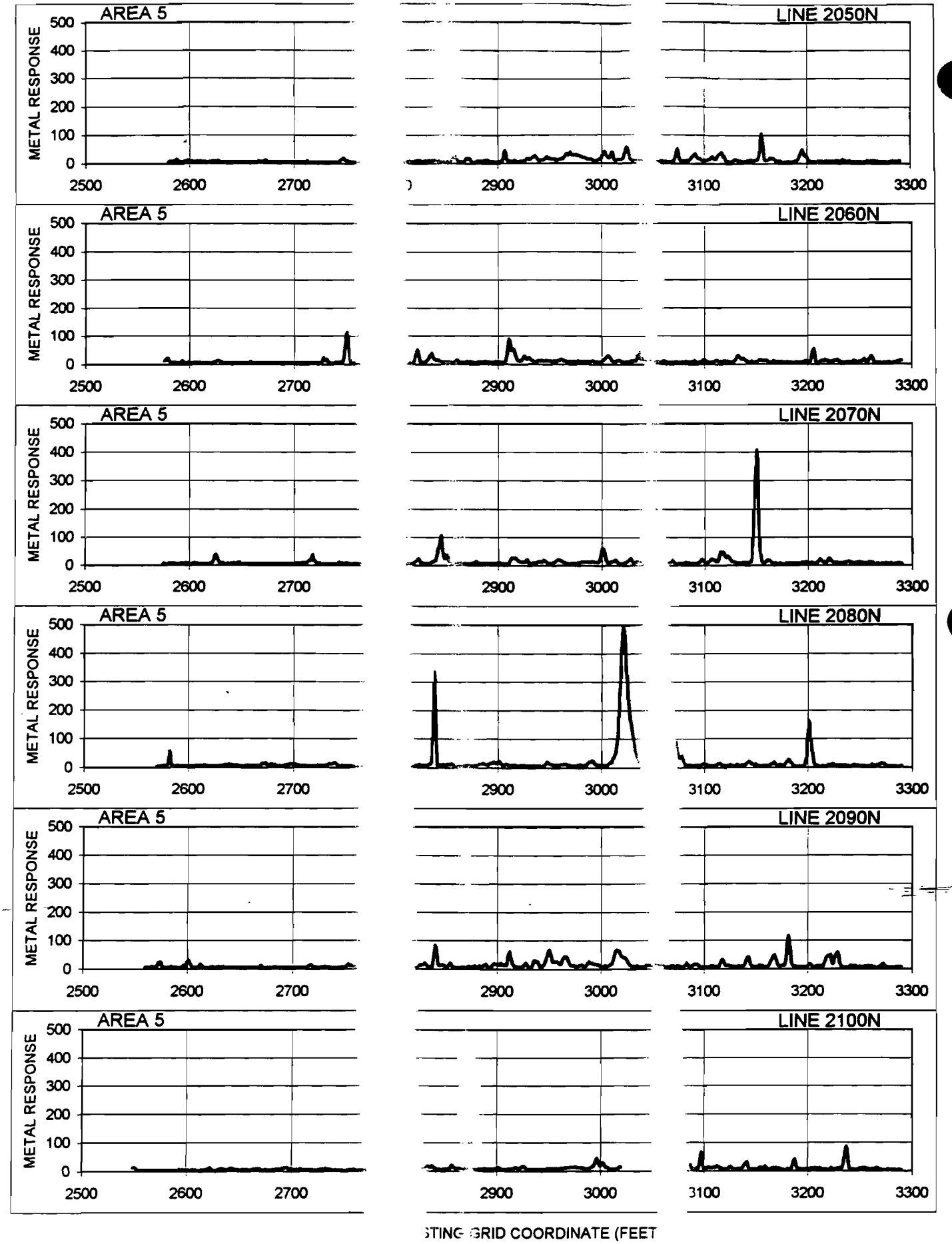
GEOSPHERE MIDWEST

FIGURE J-17



GEOSPHERE MIDWEST

FIGURE J-18



GEOSPHERE MIDWEST

FIGURE J-19

APPENDIX K

FIELD INFORMATION

This appendix includes miscellaneous information relating Geosphere Midwest's geophysical grid system (used in this report) to ABB's coordinate system. Also included are the geophysical field activity sheets.

K1. SURVEY LOCATION INFORMATION

Figure/table relating Geosphere Midwest grid to ABB map coordinates

K2. FIELD ACTIVITY SHEETS

Comparison of GSM and ABB Grid Coordinate Systems

WELL ID	ABB COORDINATES		GSM COORDINATES	
	EASTING	NORTHING	EASTING	NORTHING
1-1	404758.03	258393.75	3883	3132
1-2	404230.85	258384.67	4359	3121
1-3	405025.92	258910.43	4154	3645
4-1	403412.87	258263.10	2537	3009
4-2	403824.96	258249.98	2950	2994
4-3	403790.25	258629.99	2920	3372
5-1	403796.80	256718.88	2908	1464
5-2	404117.11	256708.30	3228	1450
5-3	403384.76	257283.74	2495	2035